CERTIFICATION

I, Michio Ogawa, Toranomon East Bldg, 7-13, Nishi-Shimbashi 1-chome, Minato-ku, Tokyo, Japan, do hereby certify that I am conversant with the English and Japanese languages and am a competent translator thereof, and I further certify that to the best of my knowledge and belief the attached English translation is a true and correct translation made by me of the Japanese patent application No. 2002-196458 filed on July 4, 2002.

Signed this on the 25th day of July, 2006

Michio Ogawa

Michio Ogawa

[Name of Document] Application for Patent

[Reference No.] J0090965

[Date of Filing] July 4, 2002

[Addressee] Commissioner of the Patent Office

[Int. Cl.] G02F 1/1335

[Inventor]

[Address] c/o Seiko Epson Corporation, 3-5, Owa 3-chome, Suwa-shi, Nagano-ken

[Name] Yasushi KASAJIMA

[Inventor]

[Address] c/o Seiko Epson Corporation, 3-5, Owa 3-chome, Suwa-shi, Nagano-ken

[Name] Toshihiko TSUCHIHASHI

[Inventor]

[Address] c/o Seiko Epson Corporation, 3-5, Owa 3-chome, Suwa-shi, Nagano-ken

[Name] Saori EISAKI

[Inventor]

[Address] c/o Seiko Epson Corporation, 3-5, Owa 3-chome, Suwa-shi, Nagano-ken

[Name] Takeyoshi USHIKI

[Inventor]

[Address] c/o Seiko Epson Corporation, 3-5, Owa 3-chome, Suwa-shi, Nagano-ken

[Name] Hiroshi WADA

[Inventor]

[Address] c/o Seiko Epson Corporation, 3-5, Owa 3-chome, Suwa-

shi, Nagano-ken

[Name] Tsuyoshi MAEDA

[Applicant for Patent]

[Id. No.] 000002369

[Name] Seiko Epson Corporation

[Agent]

[Id. No.] 100095728

[Patent Attorney]

[Name] Masataka KAMIYANAGI

[Phone No.] 0266-52-3139

[Sub-agent]

[Id. No.] 100107076

[Patent Attorney]

[Name] Eikichi FUJITSUNA

[Sub-agent]

[Id. No.] 100107261

[Patent Attorney]

[Name] Osamu SUZAWA

[Application Fees]

[Prepayment Registration No.] 013044

[Amount of Payment] 21000

[List of Documents Attached]

[Name of Document] Specification 1

[Name of Document] Drawings 1

[Name of Document] Abstract 1

[No. of General Power of Attorney] 0109826

[Proof] Required

[Designation of Document] Specification

[Title of the Invention] Display and Electronic Equipment Having the Same

[Claims]

[Claim 1] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and

absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state, and

the display unit and the display switching unit are optically adhered to each other.

[Claim 2] The display, according to Claim 1, wherein

the display unit and the display switching unit are optically adhered to each other by adhesive or an adhesive layer formed by the adhesive.

[Claim 3] The display, according to Claim 2, wherein

refraction index of the adhesive layer is in the range of 1.30 to 1.50.

[Claim 4] The display, according to Claim 2 or Claim 3, wherein

the adhesive layer is a gel material.

[Claim 5] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization

selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state, and

an anti-reflection coat is formed on the both sides of the display switching unit.

[Claim 6] The display, according to Claim 5, wherein

the anti-reflection coat is formed on a top surface of the display unit on a side of the display switching unit.

[Claim 7] A display comprising

a display unit of emitting light for forming a

predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state, and

the display switching unit is provided with a whole pixel region with a single pixel formed there and a pixel-arranged region with a plurality of pixels arranged

there, each having a predetermined shape smaller than the whole pixel region.

[Claim 8] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for

forming the display state, and

the display switching unit is provided with a region for disposing the first polarization selecting means and a region for disposing a third polarization selecting means for transmitting the first polarization, instead of the first polarization selecting means, and for absorbing the second polarization.

[Claim 9] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis

of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state, and

the display unit is provided with a region not overlapping with the display switching unit.

[Claim 10] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of

transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state, and

the display switching unit is provided with a region not overlapping with the display unit on a plane, where a plurality of pixels of a predetermined shape are arranged.

[Claim 11] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis

changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the third polarization for forming the display state, and

polarization converting means for converting the third polarization into the first polarization is provided between the display unit and the display switching unit.

[Claim 12] The display, according to Claim 11, wherein

the polarization converting means is a retardation plate.

[Claim 13] The display, according to Claim 12, wherein

the retardation plate is a plate of half wavelength.

[Claim 14] The display, according to any one of Claims 1 to 13, wherein

the second polarization selecting means is absorptive polarization selecting means for transmitting

the one polarization and absorbing the other.

[Claim 15] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state,

the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device emitting light toward the reflective display and transmitting light incident from the reflective display,

the polarized-light transmitting axis changing means includes a TN-typed liquid crystal layer and voltage application means for applying a predetermined electric field to the TN-typed liquid crystal layer in a thickness direction, and

the TN-typed liquid crystal layer has $\Delta n \cdot d$ within the range of 0.7 μm to 1.7 μm.

[Claim 16] The display, according to Claim 15, wherein

the TN-typed liquid crystal layer has the $\Delta n \cdot d$ within the range of 0.9 μm to 1.3 μm.

[Claim 17] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light

transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state,

the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device emitting light toward the reflective display and transmitting light incident from the reflective display,

the polarized-light transmitting axis changing means

includes a TN-typed liquid crystal layer and voltage application means for applying a predetermined electric field to the TN-typed liquid crystal layer in a thickness direction, and

the TN-typed liquid crystal layer has $\Delta n \cdot d$ within the range of 0.50 μm to 0.65 μm.

[Claim 18] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second

polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit includes polarized-light transmitting axis changing means for display and emits the first polarization for forming the display state,

the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display having the polarized-light transmitting axis changing means for display, disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device emitting light toward the reflective display and transmitting light incident from the reflective display,

ratio of $\alpha_m=\Delta n_m$ (λ=450nm)/Δn_m (λ=590nm) indicating wavelength distribution of refraction index anisotropy of the polarized-light transmitting axis changing means when the refraction index anisotropy for a light of wavelength λ of the polarized-light transmitting axis changing means is defined as the $\Delta n_m(\lambda)$ and $\alpha_d=\Delta n_d(\lambda$=450nm)/$\Delta n_d(\lambda$=590nm) indicating wavelength distribution of the refraction index anisotropy of the polarized-light transmitting axis changing means for display when the refraction index anisotropy for a light of wavelength λ of the polarized-light transmitting axis changing means for display is

defined as $\Delta n_d(\lambda)$, is in the range of 0.9 to 1.1.

[Claim 19] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the first polarization for forming the display state,

the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device emitting light toward the reflective display and transmitting light incident from the reflective display, and

variation amount of the refraction index anisotropy Δn_m in a visible region of the polarized-light transmitting axis changing means is within ±8% in the range of -20°C to 60°C as for the value of 25°C.

[Claim 20] The display, according to one of Claims 15 to 19, wherein

the second polarization selecting means is absorptive polarization selecting means for transmitting the one polarization and absorbing the other.

[Claim 21] The display, according to one of Claims 15 to 20, wherein

the display unit and the display switching unit are optically adhered to each other.

[Claim 22] The display, according to Claim 21, wherein

the display unit and the display switching unit are optically adhered to each other by adhesive or an adhesive layer formed by the adhesive.

[Claim 23] The display, according to Claim 22, wherein

refraction index of the adhesive layer is in the range of 1.30 to 1.50.

[Claim 24] The display, according to Claim 22 or Claim 23, wherein

the adhesive layer is a gel material.

[Claim 25] The display, according to any one of Claims 15 to 20, wherein

an anti-reflection coat is formed on the both sides of the display switching unit.

[Claim 26] The display, according to Claim 25, wherein

the anti-reflection coat is formed on a top surface of the display unit on the side of the display switching unit.

[Claim 27] The display, according to any one of Claims 15 to 26, wherein

the display switching unit is provided with a whole pixel region with a single pixel fully formed there and a pixel-arranged region with a plurality of pixels arranged there, each having a predetermined shape smaller than the whole pixel region.

[Claim 28] The display, according to one of Claims 15 to 27, wherein

the display switching unit is provided with a region for disposing the first polarization selecting means and a region for disposing a third polarization selecting means for transmitting the first polarization, instead of the first polarization selecting means, and for absorbing the second polarization.

[Claim 29] The display, according to one of Claims 15 to 28, wherein

the display unit is provided with a region not overlapping with the display switching unit.

[Claim 30] The display, according to one of Claims 15 to 29, wherein

the display switching unit is provided with a region not overlapping with the display unit on a plane and a plurality of pixels of a predetermined shape are arranged in the region.

[Claim 31] A display comprising

a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion,

wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display

unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting the light after changing the first polarization into the second polarization and a state of transmitting the light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other,

the display unit emits the third polarization for forming the display state,

the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device emitting light toward the reflective display and transmitting light incident from the reflective display, and

polarization converting means for converting the third polarization into the first polarization is provided between the display unit and the display

switching unit.

[Claim 32] The display, according to Claim 31, wherein

the polarization converting means is a retardation plate.

[Claim 33] The display, according to Claim 32, wherein the retardation plate is a plate of half wavelength.

[Claim 34] An electronic equipment comprising the display according to one of Claims 1 to 33, display driving means for controlling the display unit, and switch driving means for controlling the display switching means.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a display and an electronic equipment having the same, and especially to a structure of a display body capable of switching a display screen into a mirror-like state.

[0002]

[Prior Art]

Hitherto, there has been known a display designed in a switchable way between the usual display state and a mirror-like state by overlapping two liquid crystal

panels. For example, there is a display in which a display switching unit is provided on the side of the observation of the display unit having the same structure as that of the usual liquid crystal display and a reflective polarizing plate, a liquid crystal panel, and an absorptive polarizing plate are disposed in the display switching unit in this order from the side of the display unit. In this display, the reflective polarizing plate of the display switching unit transmits the first polarization, and reflects the second polarization having a polarization axis intersecting with the first polarization, the liquid crystal panel is designed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis, and the absorptive polarizing plate transmits, for example, the first polarization and absorbs the second polarization. The display unit emits the first polarization to the display switching unit and a predetermined display image is formed by the first polarization.

[0003]

In the display constituted in the above, when the liquid crystal panel of the display switching unit is in the state transmissive without changing the polarization

axis, since the first polarization emitted from the display unit passes through the reflective polarizing plate so to enter the liquid crystal panel and it is observed as it is as the first polarization after passing through the absorptive polarizing plate, it is possible to recognize the display mode of the display unit (display state). While, when the liquid crystal panel is in the state transmissive after changing the first polarization into the second polarization, when the first polarization emitted from the display unit passes through the reflective polarizing plate so to enter the liquid crystal panel, it is changed into the second polarization and therefore, it is absorbed by the absorptive polarizing plate and the display mode cannot be recognized. At this time, when an outside light is entered into the device, the outside light passes through the absorptive polarizing plate, hence to be the first polarization, and it passes through the liquid crystal panel, hence to be the second polarization. Therefore, it is reflected by the reflective polarizing plate, changed into the first polarization after passing through the liquid crystal panel again, and passes through the absorptive polarizing plate. Accordingly, the display surface looks like a mirror (mirror state).

[0004]

[Problems that the Invention is to Solve]

In the above-mentioned conventional display, however, the light transmitted through the liquid crystal panel provided in the display switching unit is recognized in both the display state and the mirror state. Therefore, there are such problems that contrast is deteriorated due to a boundary reflection in the both sides or the like of the display switching unit, coloring occurs caused by the optical characteristic of the display switching unit, the characteristic of the viewing angle is deteriorated, and that blur of a display image easily occurs. In any case, the conventional display cannot avoid deterioration of the display quality caused by the double structure of the display unit and the display switching unit.

[0005]

The invention is to solve the above problems, and the object of the invention is to provide a new structure of a display capable of restraining the deterioration of the display quality including contract deterioration caused by the existence of the display switching unit, coloring, reduction of viewing angle, and blur in the display having the display unit and the display switching unit.

[0006]

[Means for Solving the Problems]

In order to solve the above problems, a display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, and the display unit and the display switching unit are optically

adhered to each other.

[0007]

Since the display unit and the display switching unit are optically adhered to each other, it is possible to restrain from deteriorating the visible ability (for example, contrast) for the display mode of the display unit, owing to the boundary reflection or so between the display unit and the display switching unit. Since the display unit and the display switching unit are optically adhered to each other, one is supported by the other in the display unit and the display switching unit, thereby enhancing the rigidity or strength. Therefore, it is possible to obtain the flatness of the display screen and improve the crashworthiness of the device. Especially, the visible ability of the display mode of the display unit can be enhanced by making the display switching unit thin. However, even if the rigidity of the display switching unit is deteriorated by making it thin, the flatness and the crashworthiness can be obtained by supporting the display switching unit with the display unit.

[0008]

In the invention, it is preferable that the display unit and the display switching unit are optically adhered to each other by adhesive or an adhesive layer formed by

the adhesive. By optically adhering the display unit and the display switching unit by the adhesive or the adhesive layer formed by the adhesive, it is possible to fix the display unit and the display switching unit based on its adhesive and stick force in a state of mutually supporting them, thereby enhancing the maintaining force of the flatness and the rigidity.

[0009]

In the invention, it is preferable that the refraction index of the adhesive layer is in the range of 1.30 to 1.50. By fixing the refraction index of the adhesive layer in the range of 1.30 to 1.50, it is possible to reduce the power of the boundary reflection effectively. Generally, the refraction index can be adjusted easily in the adhesive layer by blending various types of resins.

[0010]

In the invention, it is preferable that the adhesive layer is a gel material. By forming the adhesive layer by a gel material, the adhesive layer can be deformed easily, hence to absorb a stress caused by a difference in the thermal expansion coefficient and rigidity between the display unit and the display switching unit and to prevent from a leak to the surrounding because of having retention to some extent, and its handling is easy.

[0011]

Another display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, and an anti-reflection coat is formed on the both sides of the display switching unit.

[0012]

By forming the anti-reflection coat on the both sides of the display switching unit, it is possible to restrain from deteriorating the contrast of the display mode of the display unit and the brightness of a display owing to the boundary reflection caused by providing the display unit, hence to secure the visible ability.

[0013]

In the invention, it is preferable that the anti-reflection coat is formed on a top surface of the display unit on a side of the display switching unit. By forming the anti-reflection coat also on the optical surface of the display unit, it is possible to further inhibit from deteriorating the visible ability caused by the reflection of an outside light.

[0014]

Another display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization

selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, and the display switching unit is provided with a whole pixel region with a single pixel fully formed there and a pixel-arranged region with a plurality of pixels arranged there, each having a predetermined shape smaller than the whole pixel region.

[0015]

According to the invention, by providing the whole pixel region and the pixel-arranged region in the display switching unit, it is possible to realize the display state and the mirror state as a whole in the whole pixel region and realize the display mode by combination of the display state and the mirror state in the pixel-arranged

region, separately from the display mode of the display unit.

[0016]

Further, another display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the

display state, and the display switching unit is provided with a region for disposing the first polarization selecting means and a region for disposing a third polarization selecting means for transmitting the first polarization, instead of the first polarization selecting means, and for absorbing the second polarization.

[0017]

According to the invention, by providing the region for disposing the third polarization selecting means, instead of the first polarization selecting means, in the display switching unit, the display state can be realized by the display unit in this region but the mirror state cannot be realized there. Accordingly, by arranging a plurality of pixels, in the region for disposing the third polarization selecting means, it is possible to realize the unique display mode in the display switching unit and realize the display state and the mirror state at the same time.

[0018]

Another display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light

transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, and the display unit is provided with a region not overlapping with the display switching unit.

[0019]

According to the invention, it is possible to recognize the display mode, visibly and directly in the region not overlapping with the display switching unit, provided in the display unit, without through the display switching unit. Accordingly, it is possible to recognize the display state and the mirror state at the same time.

[0020]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, and the display switching unit is provided with a region not overlapping with the display unit on a plane, and a

plurality of pixels of a predetermined shape are arranged in the region.

[0021]

According to the invention, by arranging a plurality of pixels in the region not overlapping with the display unit on a plane, in the display switching unit, it is possible to realize the mirror state and simultaneously a predetermined display mode by the display switching unit itself.

[0022]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first

polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the third polarization for forming the display state, and polarization converting means for converting the third polarization into the first polarization is provided between the display unit and the display switching unit.

[0023]

According to the invention, since the position of the display unit and the display switching unit can be changed according to the polarization converting means disposed between the display unit and the display switching unit, it is possible to change the polarized state of the emitted light in the display state and the mirror state visible through the display switching unit. For example, in order to make the display in a visible state even through the polarization sun glasses, it is necessary to emit the polarization having the vertical vibration surface from the display switching unit. Accordingly, the polarized-light transmitting axis of the second polarization selecting means must be directed in the vertical direction or the crossed angle with the

polarized-light transmitting axis thereof in the vertical direction must be small (for example, 15 degrees and less), and therefore, the position of the display switching unit is restrained. In order to restrain the position of the display switching unit thus, the position of the display unit also must be accorded depending on this. In the case of the invention, however, by providing the polarization converting means between the display unit and the display switching unit, it is possible to allow a deviation of correspondence depending on the conversion function of the polarization converting means between the position of the display unit and the position of the display switching unit, thereby changing the direction of the vibration surface of the polarization emitted from the display switching unit, for example, without changing the position of the display unit.

[0024]

In the invention, it is preferable that the polarization converting means is a retardation plate. By using the retardation plate, it is possible to change the vibration surface of the polarization easily. Especially, when the retardation plate is a plate of half wavelength, it is possible to rotate the vibration surface of the straightway polarization by 90 degrees

around the optical axis.

[0025]

In the invention, it is preferable that the second polarization selecting means is absorptive polarization selecting means for transmitting the one polarization and absorbing the other. According to this, it is possible to reduce the surface reflection of the second polarization means in the display state, thereby enhancing the quality of a display image of the display state.

[0026]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a

state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device irradiating light toward the reflective display and transmitting light incident from the reflective display, the polarized-light transmitting axis changing means includes a TN-typed liquid crystal layer and voltage application means for applying a predetermined electric field to the TN-typed liquid crystal layer in a thickness direction, and the TN-typed liquid crystal layer has $\Delta n \cdot d$ within the range of 0.7 μm to 1.7 μm.

[0027]

According to the invention, since the illuminating device illuminates the reflective display, the brightness of the reflective display can be enhanced and a display

by use of an outside light is enabled without a light of the illuminating device, thereby decreasing the power consumption. Especially, since the polarized-light transmitting axis changing means includes the TN-typed liquid crystal layer and the $\Delta n \cdot d$ of the TN-typed liquid crystal layer is in the range of 0.7 μm to 1.7 μm, it is possible to reduce the coloring of the display state and the mirror state formed by the display unit and brighten the display. Further, since the $\Delta n \cdot d$ is small, it is possible to reduce the blur of the display image and obtain the range of the viewing angle to some degree.

[0028]

In this case, it is preferable that the TN-typed liquid crystal layer has the $\Delta n \cdot d$ within the range of 0.9 μm to 1.3 μm. Since the TN-typed liquid crystal layer has the $\Delta n \cdot d$ within this range, the coloring can be further reduced and the brighter display is possible. Especially, since the coloring in the mirror state is remarkably improved, the ideal mirror state can be realized.

[0029]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one

portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device irradiating light toward the reflective display and transmitting light incident from the reflective display, the polarized-light transmitting

axis changing means includes a TN-typed liquid crystal layer and voltage application means for applying a predetermined electric field to the TN-typed liquid crystal layer in a thickness direction, and the TN-typed liquid crystal layer has $\Delta n \cdot d$ within the range of 0.50 μm to 0.65 μm.

[0030]

According to the invention, since the reflective display is illuminated by the illuminating device, the brightness of the reflective display can be enhanced and the display by use of an outside light is enabled without a light of the illuminating device, thereby reducing the power consumption. Especially, since the polarized-light transmitting axis changing means includes the TN-typed liquid crystal layer and the $\Delta n \cdot d$ of the TN-typed liquid crystal layer is in the range of 0.50 μm to 0.65 μm, it is possible to obtain a wide viewing angle in the display state and the mirror state.

[0031]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light

transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit includes polarized-light transmitting axis changing means for display and emits the first polarization for forming the display state, the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display having the polarized-light transmitting axis changing means for display, disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device irradiating light toward the reflective display and transmitting light incident from

the reflective display, ratio of $\alpha_m=\Delta n_m$ (λ=450nm)/Δn_m (λ=590nm) indicating wavelength distribution of refraction index anisotropy of the polarized-light transmitting axis changing means when the refraction index anisotropy for a light of wavelength λ of the polarized-light transmitting axis changing means is defined as $\Delta n_m(\lambda)$ and $\alpha_d=\Delta n_d(\lambda$=450nm)/$\Delta n_d(\lambda$=590nm) indicating wavelength distribution of the refraction index anisotropy of the polarized-light transmitting axis changing means for display when the refraction index anisotropy for a light of wavelength λ of the polarized-light transmitting axis changing means for display is defined as $\Delta n_d(\lambda)$, is in the range of 0.9 to 1.1.

[0032]

According to the invention, since the reflective display is illuminated by the illuminating device, the brightness of the reflective display can be enhanced and the display by use of an outside light is possible without a light of the illuminating device, thereby reducing the power consumption. Especially, since the ratio of the wavelength distribution of the polarized-light transmitting axis changing means of the display switching unit to the wavelength distribution of the refraction index anisotropy of the polarized-light transmitting axis changing means for display of the

display unit is in the range of 0.9 to 1.1, a difference in the wavelength distribution characteristic of the refraction index anisotropy between the display unit and the display switching unit is reduced, and therefore, it is possible to restrain from deteriorating the brightness of the display caused by providing the display switching unit and reduce the coloring of the display state.

[0033]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis

of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the first polarization for forming the display state, the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device irradiating light toward the reflective display and transmitting light incident from the reflective display, and variation amount of the refraction index anisotropy Δn_m in a visible region of the polarized-light transmitting axis changing means is within ±8% in the range of -20°C to 60°C as for the value of 25°C.

[0034]

According to the invention, since the reflective display is illuminated by the illuminating device, the brightness of the reflective display can be enhanced and the display by use of an outside light is possible without a light of the illuminating device, thereby reducing the power consumption. Especially, when the variation amount of Δn_m exceeds 8%, the display characteristics such as color tone and contrast are

rapidly deteriorated, but by fixing the variation within ±8% in the range of -20°C to 60°C as for the value of 25°C, the transmittance of the display switching unit can be stable and the reduction of the transmittance caused by a temperature change can be restrained. Especially, in order to maintain the display characteristics, it is preferable that the variation is within ±5%.

[0035]

In the invention, it is preferable that the second polarization selecting means is absorptive polarization selecting means for transmitting the one polarization and absorbing the other. According to this, the surface reflection of the second polarization means in the display state can be reduced, thereby further enhancing the quality of the display image in the display state.

[0036]

In the invention, it is preferable that the display unit and the display switching unit are optically adhered to each other.

[0037]

In this case, it is preferable that the display unit and the display switching unit are optically adhered to each other by adhesive or an adhesive layer formed by the adhesive.

[0038]

It is preferable that the refraction index of the adhesive layer is in the range of 1.30 to 1.50.

[0039]

It is preferable that the adhesive layer is a gel material.

[0040]

In the invention, it is preferable that an anti-reflection coat is formed on the both sides of the display switching unit. In this case, it is preferable that the anti-reflection coat is formed on a top surface of the display unit on the side of the display switching unit.

[0041]

It is preferable that the display switching unit is provided with a whole pixel region with a single pixel fully formed there and a pixel-arranged region with a plurality of pixels arranged there, each having a predetermined shape smaller than the whole pixel region.

[0042]

It is preferable that the display switching unit is provided with a region for disposing the first polarization selecting means and a region for disposing a third polarization selecting means for transmitting the first polarization, instead of the first polarization selecting means, and for absorbing the second

polarization.

[0043]

It is preferable that the display unit is provided with a region not overlapping with the display switching unit.

[0044]

It is preferable that the display switching unit is provided with a region not overlapping with the display unit on a plane and that a plurality of pixels of a predetermined shape are arranged in the region.

[0045]

A display of the invention comprises a display unit of emitting light for forming a predetermined display state and a display switching unit disposed in a way of overlapping with the display unit at least in one portion, wherein the display switching unit includes first polarization selecting means, polarized-light transmitting axis changing means, and second polarization selecting means sequentially disposed from the display unit toward an observation side, the first polarization selecting means transmitting a first polarization and reflecting a second polarization having a polarization axis intersecting with a polarization axis of the first polarization, the polarized-light transmitting axis changing means being formed in a switchable way between a

state of transmitting light after changing the first polarization into the second polarization and a state of transmitting light without changing the polarization axis of the incident light substantially, the second polarization selecting means transmitting one of the first polarization and the second polarization and absorbing or reflecting the other, the display unit emits the third polarization for forming the display state, the display unit includes an illuminating device disposed on the side of the display switching unit and a reflective display disposed on the opposite side of the illuminating device away from the display switching unit, the illuminating device irradiating light toward the reflective display and transmitting light incident from the reflective display, and polarization converting means for converting the third polarization into the first polarization is provided between the display unit and the display switching unit.

[0046]

In the invention, it is preferable that the polarization converting means is a retardation plate. In this case, it is preferable that the retardation plate is a plate of half wavelength.

[0047]

An electronic equipment of the invention comprises

one of the above-mentioned displays, display controlling means for controlling the display unit, and display switch controlling means for controlling the display switching unit. Since this display can switch the display state and the mirror state as mentioned above, the display screen can be used as a mirror, and therefore, it is preferable that the display is formed as a portable electronic equipment such as a portable telephone and a portable information terminal.

[0048]

[Mode for Carrying Out the Invention]

Embodiments of a display and an electronic equipment according to the invention will be described in detail with reference to the accompanying drawings.

[0049]

[Basic structural example of the embodiments]

At first, basic structural examples applicable to the respective embodiments according to the invention will be described with reference to Fig. 1 to Fig. 4.

[0050]

(First Structural example) A display 100 shown in Fig. 1 is formed by a display switching unit 120 and a display unit 110 overlapping flatly. The display unit 110 and the display switching unit 120 may overlap with each other at least in one portion.

[0051]

Here, the display unit 110 may have any structure capable of forming the display mode of a predetermined image and the like on the display switching unit 120 side (various display means such as EL (electroluminescence) element, PDP (plasma display panel) device, and FED (field emission device)), and in the case of this embodiment, the display unit designed for a liquid crystal display is used.

[0052]

As the liquid crystal mode of the display unit 110, the TN (Twisted Nematic) mode, the STN (Super Twisted Nematic) mode, and the ECB (Electrically Controlled Briefringence) mode are preferable. Since the display means by these liquid crystal modes are designed to realize the display mode by using a polarizing plate, it can obtain a high display quality with a comparatively low driving voltage, and especially, it is preferable in case of mounting the above in a portable electronic equipment.

[0053]

A driving mode of the display unit 110 may be an active driving mode such as active matrix drive using an active element including TFT (Thin Film Transistor) and TFD (Thin Film Diode), or a passive driving mode such as

simple driving and multiplex driving without using the above active element.

[0054]

A panel of the display unit 110 may be a reflective panel, reflective semi-transparent panel, or a transparent panel. In the case of the reflective panel, a reflective surface is formed on the opposite side of the observation of optical elements. In case of the reflective semi transparent panel, there are a case of forming the reflective surface with a reflective semi transparent material such as a half mirror and a case of providing an aperture on the reflective surface for every pixel or segment.

[0055]

The structure of the display unit 110 of the embodiment is described more specifically. For example, as illustrated in Fig. 1, the display unit 110 includes a polarizing plate 111, a retardation plate 112, a liquid crystal panel 113, a polarizing plate 114, and a back light 115 in this order from the side of the display switching unit 120. In case of forming the display unit 110 as the reflective liquid crystal display, a reflective plate may be disposed instead of the back light 115. This reflective plate may be disposed inside the liquid crystal panel 113.

[0056]

The liquid crystal panel 113 is formed by interposing a liquid crystal layer 113c between two substrates 113a and 113b. The two substrates 113a and 113b are stuck together by a seal material or the like with a predetermined interval (for example, about 3 to 10 μm). Electrodes, not illustrated, are formed on the inner surfaces of the substrates 113a and 113b, and these electrodes are adopted to apply an electric field to the liquid crystal layer 113c. A liquid crystal display of reflective semi-transmissive type can be formed by a reflective layer having a semi-transmittance of visible light and a reflective layer having a small aperture for every pixel inside the liquid crystal panel 113.

[0057]

The polarizing plates 111 and 114 are arranged at some necessary positions (for example, at the crossed-Nicol position) on the liquid crystal display. As the polarizing plates 111 and 114, there is used a known absorptive polarizing plate for transmitting a polarization component having a vibration surface in parallel to the polarized-light transmitting axis and absorbing a polarization component having a vibration surface in parallel to the direction of intersecting with the polarized-light transmitting axis (preferably at

right angles).

[0058]

The back light 115 may be of any type that can illuminate the liquid crystal panel 113 backwardly with substantially uniform illumination. There are, for example, a light emissive-typed end back light including an optical waveguide and a light source disposed in the end surface portion of the optical waveguide, and a light emissive-typed rear back light including an optical waveguide and a light source disposed in a rear surface of the optical waveguide.

[0059]

While, the display switching unit 120 includes a reflective polarizing plate 121, a liquid crystal panel 122, and a polarizing plate 123 disposed in this order from the display unit 110 to the observation side. The reflective polarizing plate 121 is to transmit a polarizing component having a vibration surface in parallel to the polarized light transmitting axis, and to reflect a polarizing component having a vibration surface in parallel to the direction of intersecting with the polarized-light transmitting axis (preferably at right angles). As the reflective polarizing plate, a laminate layering double reflex polymer films of several different types, which is disclosed in International Application

Laid-Open No. WO95/27919, or one having a plate of one quarter wavelength disposed on the both sides of the cholesteric liquid crystal can be used. As the above laminated there is a layered film whose trade name is DBEF produced by 3M Co.

[0060]

The liquid crystal panel 122 is formed by interposing a liquid crystal layer 122c between two substrates 122a and 122b. Transparent electrodes, not illustrated, are formed respectively on the inner surfaces of the substrates 122a and 122b, and these transparent electrodes are adopted to apply a predetermined electric field to the liquid crystal layer 122c. In case of the liquid crystal panel 122, each one of the integral transparent electrodes may be provided on both sides of the liquid crystal layer 122c so as to cover substantially the whole surfaces of the effective display region. Alternatively, several transparent electrodes may be respectively provided on the both sides of the liquid crystal layer 122c so as to supply a potential independently.

[0061]

The polarizing plate 123 is, for example, a known absorptive polarizing plate for transmitting a polarization component having a vibration surface in

parallel to the polarized-light transmitting axis and absorbing a polarization component having a vibration surface in parallel to the direction intersecting with the polarized-light transmitting axis (preferably at right angles), in the same way as mentioned above. A reflective polarizing plate formed similarly to the reflective polarizing plate 121 can be also used.

[0062]

It is preferable that the form of the liquid crystal panel 122 may be the TN typed panel or the STN typed panel. As a substrate for forming the panel structure, glass (including quartz) or resin (plastic) may be used, or glass may be used on one side and resin may be used on the other side. By using the resin for a substrate, it is possible to make the panel thinner and improve the shockproof. In case of using the resin for a substrate, since it becomes difficult to obtain the flatness of the liquid crystal panel 122, it is preferable that it should be optically adhered to the display unit 110, as described later. For example, by using the transparent resin adhesive having a proper refractive index, the liquid crystal panel 122 can be adhered to the display unit 110 through an adhesive layer free from optical influence substantially.

[0063]

It is preferable that the polarized-light transmitting axis of the reflective polarizing plate 121 of the display switching unit 120 and the polarized-light transmitting axis of the polarizing plate 111 of the display unit 110 are basically arranged in the same direction. Even if the polarized-light transmitting axis of the reflective polarizing plate 121 and the polarized-light transmitting axis of the polarizing plate 111 are not in one accord, when the crossed angle of the both polarized-light transmitting axes is 15 degrees and less, the display switching function described below can be achieved.

[0064]

In the display 100 of the embodiment, it is possible to control the density of an electric field applied to the liquid crystal layer 122c of the liquid crystal panel 122 of the display switching unit 120, and make the display switching unit 120 into a transmissive state or an outside light reflective state by switching application of an electric field.

[0065]

By way of example, the case will be described that the liquid crystal panel 122 of the display switching unit 120 is the TN typed liquid crystal panel and the polarized-light transmitting axis of the reflective

polarizing plate 121 is arranged to intersect with the polarized-light transmitting axis of the polarizing plate 123 at right angles. In this case, when no electric field is applied to the liquid crystal layer 122c, the nematic liquid crystal within the liquid crystal layer 122c is in a twist state of 90 degrees and basically it has an optical rotation of 90 degrees. Accordingly, when an outside light is entered into the display switching unit 120, a transmissive light becomes a straightway polarization having a vibration surface in parallel with the polarized-light transmitting axis of the polarizing plate 123 by passing through the polarizing plate 123, and the straightway polarization is converted into a straightway polarization having a vibration surface crossing the polarized-light transmitting axis of the polarizing plate 123 at right angles by passing through the liquid crystal panel 122. This straightway polarization is transmitted through the reflective polarizing plate 121 because of having a vibration surface in parallel with the polarized-light transmitting axis of the reflective polarizing plate 121, and entered into the display unit 110. The light entered into the display unit 110 is transmitted through the polarizing plate 111, and when the display unit 110 forms the reflective display (for example, reflective or reflective

semi-transmissive liquid crystal display), the light becomes at least one of the light forming a display image of the display unit 110.

[0066]

While, a light outgoing from the display unit 110 (namely, the light forming a display image of the display unit 110) becomes a straightway polarization having a vibration surface in parallel with the polarized-light transmitting axis of the polarizing plate 111 by the polarizing plate 111 of the display unit 120. Accordingly, the straightway polarization is transmitted through the reflective polarizing plate 121 and entered into the liquid crystal panel 122. Since the vibration surface of the straightway polarization is rotated by 90 degrees by passing through the liquid crystal panel 122, the straightway polarization is transmitted through the polarizing plate 123 after passing through the liquid crystal panel 122, and supplied to the observation side. Accordingly, the display image formed by the display unit 110 is transmitted through the display switching unit 120 as it is and it becomes visible (display state).

[0067]

When an electric field of a predetermined threshold and more is applied to the liquid crystal layer 122c in the liquid crystal panel 122, since the liquid crystal

within the liquid crystal layer 122c is released from the twist state, the liquid crystal panel 122 loses the optical rotation for the light transmitted in the direction of the optical axis. Accordingly, in this case, when an outside light is entered into the display switching unit 120, the straightway polarization created by passing through the polarizing plate 123 in the same way as mentioned above, passes through the liquid crystal panel 122 without changing the vibration surface and therefore, it is reflected by the reflective polarizing plate 121. Since the reflective light passes through the liquid crystal panel 122 again without changing its vibration surface, it is transmitted through the polarizing plate 123 as it is and becomes visible.

[0068]

The light outgoing from the display unit 110 is a straightway polarization having a vibration surface in parallel with the polarized-light transmitting axis of the polarizing plate 111 in the same way as mentioned above. Since it passes through the reflective polarizing plate 121 of the display switching unit 120 as it is and passes through the liquid crystal panel 122 without changing its vibration surface, it is absorbed by the polarizing plate 123. Accordingly, the display image of the display unit 110 cannot be recognized visibly

outwardly.

[0069]

As mentioned above, since the liquid crystal panel 122 turns into the electric field applied state in the display switching unit 120, one of the outside light is reflected and the light entered from the display unit 110 is absorbed by the polarizing plate 123 and not visible from the outside, thereby turning the display screen into a mirror surface state (mirror state).

[0070]

(Second structural example) A display 200 of the second structural example according to the invention will be described. Fig. 2 is a schematic constitutional view showing the schematic structure of the display 200. The display 200 comprises a display unit 210 and a display switching unit 220 similarly to the first embodiment. The display unit 210 includes a retardation plate 221, a liquid crystal panel 213 (including substrates 213a and 213b and a liquid crystal layer 213c), a polarizing plate 214, and a back light 215, similarly to the first embodiment. In case of the display unit 210 designed as the reflective liquid crystal display, the back light 215 is not necessary, like the first embodiment. This embodiment is different from the first embodiment in that a polarizing plate is not provided on the observation

side (the side of the display switching unit 220) of the liquid crystal panel 213 in the display unit 210.

[0071]

While, the display switching unit 220 includes a reflective polarizing plate 221, a liquid crystal panel 222 (substrates 222a and 222b and a liquid crystal layer 222c), and a polarizing plate 223 from the side of the display unit 210 to the observation side, similarly to the first embodiment. Since the relationship among these components and the contents of these components of the display switching unit 220 are completely identical to the first embodiment, the description thereof is omitted.

[0072]

Although the polarizing plate of the display unit 210 on the observation side is omitted in this embodiment, the function of the polarizing plate can be achieved by the reflective polarizing plate 221 of the display switching unit 220. Namely, since the reflective polarizing plate 221 transmits a polarization component having a vibration surface in parallel with its polarized-light transmitting axis and reflects a polarization component having a vibration surface intersecting with the polarized-light transmitting axis (preferably at right angles), when the polarized-light transmitting axis of the reflective polarizing plate 221

is arranged in the substantially same direction as the polarized-light transmitting axis of the polarizing plate that would be positioned in the display unit 210 at the observation side, the same effect as that of the first embodiment can be obtained basically. Accordingly, it is possible to obtain a display state of the display unit 210 by the reflective polarizing plate 221 of the display switching unit 220, similarly to the first embodiment, as well as to obtain a mirror state by the reflective polarizing plate 221.

[0073]

(Third structural example) A display 300 of a third embodiment according to the invention will be described with reference to Fig. 3. The display 300 comprises a display unit 310 and a display switching unit 320 in the same way as mentioned above. Since the display switching unit 320 includes a reflective polarizing plate 321, a liquid crystal panel 322 (including substrates 322a and 322b and a liquid crystal layer 322c), and a polarizing plate 323, similarly to the above respective embodiments, the description thereof is omitted.

[0074]

This embodiment is different from the above respective embodiments in that the display unit 310 is formed by a reflective semi-transmissive liquid crystal

display. The display unit 310 includes a polarizing plate 311, a retardation plate 312, a liquid crystal panel 313, a retardation plate 316, a polarizing plate 314, and a back light 315 disposed in this order from the side of the display switching unit 320.

[0075]

The liquid crystal panel 313 includes a liquid crystal layer 313c interposed between two substrates 313a and 313b. A reflective layer 313d is formed on the inner surface of the substrate 313b (namely, the substrate opposite to the observation side) on the side of the back light 315. The reflective layer 313d is formed by a thin film made from reflective material such as aluminum and silver, or their alloy. The reflective layer 313d is provided with each aperture 313e as for every pixel for forming a display image. A light entered into the liquid crystal panel 313 from the observation side is reflected by the reflective layer 313d and the light entered from the back light 315 is transmitted through the aperture 313e.

[0076]

In this display 300, an outside light entered from the observation side (the side of the display switching unit 320) becomes a straightway polarization having a vibration surface in parallel with the polarized-light

transmitting axis of the polarizing plate 311 through the polarizing plate 311, after passing through the retardation plate 312 and entering into the liquid crystal panel 313, it is transmitted through the liquid crystal layer 313c and reflected by the reflective layer 313d. The reflective light is transmitted through the liquid crystal layer 313c again and transmitted through the retardation plate 312, and then, entered into the polarizing plate 311. The polarization state of the light entered into the polarizing plate 311 is changed according to the voltage application state of the liquid crystal layer 313c, and according to the change state, whether it is transmitted through the polarizing plate 311 or absorbed by the polarizing plate 311 is determined.

[0077]

While, the light emitted from the back light 315 passes through the polarizing plate 314 and becomes a straightway polarization having a vibration surface in parallel with the polarized-light transmitting axis thereof, passing through the retardation plate 316 and entering into the liquid crystal layer 313c through the aperture 313e of the liquid crystal panel 313. The light passing through the liquid crystal layer 313c enters into the polarizing plate 311 after passing through the

retardation plate 312. The polarization state of the light incident to the polarizing plate 311 is changed according to the voltage application state of the liquid crystal layer 313c and whether it is transmitted through the polarizing plate 311 or absorbed by the polarizing plate 311 is determined according to the change state.

[0078]

Also in this embodiment, whether the display switching unit 320 is in a transmissive state or a reflective state is determined by the voltage or the presence of the voltage applied to the liquid crystal layer 322c within the liquid crystal panel 322. Accordingly, when the display switching unit 320 is in a transmissive state, the display image formed on the display unit 310 can be recognized visibly. The display image is formed as a reflective display without help of the back light 315 when it is bright in the surroundings, while it is formed as a transmissive display by the light of the back light 315 when it is dark in the surroundings.

[0079]

(Fourth structural example) A display 400 of a fourth embodiment according to the invention will be described with reference to Fig. 4. The display 400 comprises a display unit 410 and a display switching unit

420 similarly to the above respective embodiments. Since the display switching unit 420 includes a reflective polarizing plate 421, a liquid crystal panel 422 (including substrates 422a and 422b and a liquid crystal layer 422c), and a polarizing plate 423, similarly to the above respective embodiments, the description thereof is omitted.

[0080]

The display unit 410 includes a retardation plate 412, a liquid crystal panel 413, a retardation plate 416, a polarizing plate 414, and a back light 415, similarly to the above third embodiment. The liquid crystal panel 413 includes substrates 413a and 413b, a liquid crystal layer 413c, a reflective layer 413d, and an aperture 413e, similarly to the above third embodiment. This display unit 410, however, is different from that of the above in that the polarizing plate provided in the third embodiment is not provided on the observation side (the side of the display switching unit 420). The display 400 is designed to direct the polarized-light transmitting axis of the reflective polarizing plate 421 of the display switching unit 420 toward the direction coincident with the polarized-light transmitting axis of the polarizing plate to be positioned on the observation side of the display unit 410.

[0081]

Although the polarizing plate on the observation side is not positioned in the display unit 410, the function of the polarizing plate can be achieved by the reflective polarizing plate 421 in the display switching unit 420, similarly to the second embodiment, and therefore, the same function and effect as those of the above third embodiment can be achieved.

[0082]

Although the basic structural examples that can be used for the embodiments of the invention have been described, the above structural examples 1 to 4 are only examples and actually various modifications can be made, with the essential components of the invention provided there, without departing from the sprit of the invention.

[0083]

[First Embodiment]

A display according to a first embodiment of the invention will be described with reference to Fig. 5. This first embodiment is formed based on the first structural example, and in Fig. 5, not-essential components (for example, retardation plate and back light) are properly omitted and the corresponding reference marks are attached to the corresponding components to the first structural example.

[0084]

In this embodiment, in the display unit 110, the polarizing plate 111, the liquid crystal panel 113, and the polarizing plate 114 are mutually stuck together in an integral way, and in the display switching unit 120, the reflective polarizing plate 121, the liquid crystal panel 122, and the polarizing plate 123 are mutually stuck together in an integral way. The integrated portion of the display unit 110 and the integrated portion of the display switching unit 120 are optically adhered to each other by an adhesive layer 131. Optical adhesion means that the display unit 110 is adhered to the display switching unit 120 in the substantially same state as in case where nothing optical exists therebetween. Here, adhesion means that the display unit 110 is directly or indirectly in contact with the display switching unit 120 in a way capable of mutually supporting each other.

[0085]

The adhesive layer 131 is basically made from a transparent material having a good transmittance (for example, 90% and more) all over the whole visible region and the refractive index of the adhesive layer 131 is selected to reduce the most of reflection in the boundary between the top surface of the display unit 110 and the

rear surface of the display switching unit 120. It is preferable that the refractive index of the adhesive layer 131 is within the range of 1.30 to 1.50. When the refractive index is apart from this range, the reflection is increased in the boundary between the polarizing plate 111 and the reflective polarizing plate 121, or the glass substrates of the liquid crystal panel, thereby deteriorating the display quality. In this case, it is preferable that the thickness of the adhesive layer 131 is 100 μm and less.

[0086]

The adhesive layer 131 is made from the adhesive or the stick such as epoxy resin or acrylic resin. Especially, as the material forming the adhesive layer 131, a gel material is preferable. Since the display unit 110 and the display switching unit 120 are adhered to each other in a relatively movable way, because of forming the adhesive layer 131 by the gel material, it is possible to absorb a stress occurring between the both caused by a difference in coefficient of thermal expansion and rigidity, and even when the liquid crystal panel is made from a fragile material such as glass, it is possible to restrain the same panel from being damaged, thereby enhancing the crashworthiness.

[0087]

Although the first embodiment has been described according to the first structural example as mentioned above, it may be formed according to one of the above second to fourth structural examples. Alternatively, another structure, than the above structural examples, may be adopted, as far as it includes the essential components of the invention.

[0088]

[Second Embodiment]

A display according to a second embodiment of the invention will be described with reference to Fig. 6. The second embodiment is formed according to the second structural example as mentioned above. In this embodiment, the display unit 210 is not optically adhered to the display switching unit 220, but they are firmly supported by a case and the like, not illustrated, in a separate state.

[0089]

In the embodiment, an anti-reflection coat 232 is formed on the surface of the display unit 210 on the side of the display switching unit 220 and an anti-reflection coat 233 is formed on the surface of the display switching unit 220 on the side of the display unit 210. Further, an anti-reflection coat 234 is formed on the surface of the display switching unit 220 on the side

opposite to the display unit 210 (on the observation side).

[0090]

The above anti-reflection coats (AR coat) 232, 233, and 234 are formed by a single layer film coated in about one quarter thickness of the wavelength of the visible region by evaporation method and the like and a multi-layer film of alternately laminating A-layer and B-layer that are different in refraction index and have the thickness of about one quarter of the wavelength of the visible region. In case of multi-layer film, by changing the thickness of the A-layer and the B-layer little by little, it is possible to reduce the reflection index extremely over the wide range of the visible region. As the material forming the anti-reflection coat, an inorganic compound including magnesium fluoride and silicon dioxide, and an organic compound including acrylic resin and epoxy resin can be used and a film can be formed by evaporation, sputtering, and CVD methods.

[0091]

In the embodiment, in a display state where a light outgoing from the display unit 210 can be transmitted through the display switching unit 220 and visible, it is possible to restrain from deteriorating the display quality, such as reducing the contrast and reducing the

brightness of the display, caused by reflection of an outside light on the surface of the observation side of the display switching unit 220, reflection of an outside light on the surface of the display unit 210 on the side of the display switching unit 220, and reflection of a display light on the surface of the display switching unit 220 on the side of the display unit 210.

[0092]

Although the second embodiment has been described according to the second structural example as mentioned above, it may be formed according to any example of the first, the third and the fourth structural examples. Another structure than the above structural examples may be adopted for this embodiment, as far as it includes the essential components of the invention.

[0093]

[Third Embodiment]

A third embodiment according to the invention will be described with reference to Fig. 7. The embodiment is formed according to the first structural example. In the embodiment, two regions 120A and 120B are provided in the display switching unit 120. In the region 120A, single electrodes 122d and 122e for applying an electric field to the liquid crystal layer 122c are fully formed on the inner surfaces of the substrates 122a and 122b of the

liquid crystal panel 122, and a single pixel is formed in the region 120A by these electrodes 122d and 122e. On the contrary, a plurality of electrodes 122f and 122g smaller than the electrodes provided in the region 120A are arranged in the region 120B and a plurality of pixels are arranged there. Accordingly, in the region 120A, the optical state of the liquid crystal layer 122c is switched in the block, while in the region 120B, the optical state of the liquid crystal layer 122c can be controlled for every pixel formed by a plurality of the electrodes 122f and 122g. Therefore, in the region 120B, a desired display is possible by switching a display state and a mirror state according to the control of the plural pixels alternately.

[0094]

The plural pixels within the region 120B may be formed in a so-called dot-matrix shape or they may be formed in a segment shape having a specific plane. In any case, in the display switching unit 120, a display mode different from that of the display unit 110 can be displayed, namely, a display mode different from that of the display unit 110 can be realized by switching the display state and the mirror state, and a display apparently formed on a different position from the display unit 110 can be realized because of a display on

the display switching unit positioned nearer to the observation side than the display unit. Therefore, it is possible to expand variation of the display mode on a display screen.

[0095]

While, in the liquid crystal panel 113 provided in the display unit 110 shown in Fig. 7, a plurality of electrodes 113d and 113e are arranged on the inner surfaces of the substrates 113a and 113b, thereby arranging a plurality of pixels in a dot-matrix shape.

[0096]

In Fig. 7, the electrodes 113f and 113g and the electrodes 122f and 122g are shown schematically, and actually various structures can be adopted depending on the structure of the liquid crystal panel 122. For example, when adopting a passive matrix-typed panel structure, the electrode 122f and the electrode 122g mutually intersect with each other and a pixel region is formed on the intersecting plane portion. When adopting an active matrix-typed panel structure, there is a case of forming a pixel electrode independent for every pixel on the inner surface of one substrate.

[0097]

Although the third embodiment has been described according to the first structural example as mentioned

above, it may be formed based on any example of the second to the fourth structural examples. Another structure than the above examples may be adopted, as far as it includes the essential components of the invention.

[0098]

[Fourth Embodiment]

A display of a fourth embodiment according to the invention will be described with reference to Fig. 8. This embodiment is shown according to the second structural example. In this embodiment, a region 210A overlapping with the display switching unit 220 on a plane and a region 210B not overlapping with the display switching unit 220 are provided in the display unit 210. Accordingly, in the region 210B, the display unit 210 can be recognized visibly without through the display switching unit 220.

[0099]

In the liquid crystal panel 213 of the display unit 210, a plurality of electrodes 213d and 213e are arranged and a plurality of pixels are arranged in a dot-matrix shape. In the liquid crystal panel 222 of the display switching unit 220, single electrodes 222d and 222e are formed and a single pixel is formed on the whole surface.

[0100]

In this embodiment, since the display unit 210 is

visible in the region 210B without through the display switching unit 220, the contents displayed by the display unit 210 can be recognized visibly even if the display switching unit 220 is in a mirror state. Accordingly, it is possible to realize the mirror state and the display state at the same time and it is possible to improve the visible ability of the region 210B by providing the region 210B which can be directly recognized visibly without through the display switching unit 220. For example, a finer pixel structure can be provided in the region 210B than in the region 210A, thereby realizing a display mode of larger information amount in the more visible region 210B.

[0101]

Although the second embodiment has been described according to the second structural example as mentioned above, it may be formed based on any example of the first, the third, and the fourth structural examples. Another structure than the above examples may be adopted, as far as it includes the essential components of the invention.

[0102]

[Fifth Embodiment]

A fifth embodiment according to the invention will be described with reference to Fig. 9. Since the

embodiment basically has the same structure as the third embodiment, the same reference numerals are attached to the same components and the description thereof is omitted.

[0103]

This embodiment is different from the third embodiment in that a reflective polarizing plate 121 disposed in the display switching unit 120 doesn't cover the whole display screen but covers only the region 120A with the single pixel formed. Instead of the reflective polarizing plate 121, an absorptive polarizing plate 124 is disposed in the region 120B with a plurality of pixels arranged. Here, the polarizing plate 124 is arranged in that its polarized-light transmitting axis is positioned in the same direction as the polarized-light transmitting axis of the reflective polarizing plate 121. Namely, the polarizing plate 124 transmits a polarization component that the reflective polarizing plate 121 transmits and absorbs a polarization component that the reflective polarizing plate 121 reflects.

[0104]

Since the absorptive polarizing plate 124 is provided in the region 120B of the display switching unit 120, this embodiment has a function capable of switching a light emissive state and a light non-emissive state

similarly to the usual liquid crystal display panel, and as a result, it is possible to realize the usual display mode different from the switching operation of the display state and the mirror state in the region 120A. Since the region 120B may be designed so as to visibly recognize a display mode formed by the display switching unit 120 or a display mode formed by both of the display unit 110 and the display switching unit 120, it is possible to expand variation of the display mode and the display position.

[0105]

Although the fifth embodiment has been described according to the first structural example as mentioned above, it may be formed based on any example of the second to the fourth structural examples. Another structure than the above examples may be adopted, as far as it includes the essential components of the invention.

[0106]

[Sixth Embodiment]

A sixth embodiment according to the invention will be described with reference to Fig. 10. In this embodiment, a region 220A overlapping with the display unit 210 on a plane and a region 220B not overlapping with the display unit 210 on a plane are provided in the display switching unit 220. In the region 220A, a single

pixel is formed by electrodes 222d and 222e covering substantially the whole surface of the liquid crystal panel 222. While, in the region 220B, a plurality of pixels are arranged by forming a plurality of electrodes 222f and 222g there.

[0107]

Similarly to the fifth embodiment, a reflective polarizing plate 221 is disposed in the region 220A and an absorptive polarizing plate 224 is disposed in the region 220B, on the side of the display unit 210 of the liquid crystal panel 222. Even when the reflective polarizing plate 221 is designed to be disposed in the region 220B, it is possible to realize a display mode by the display switching unit 220 as well as a function described later although the display mode is different.

[0108]

Further, a liquid crystal panel 213 with a plurality of pixels having a plurality of electrodes 213d and 213e arranged there, formed in the same way as those of the third to the fifth embodiments excepting the size in the display switching unit 220, is provided in the display unit 210.

[0109]

In this embodiment, the region 220A functions in the same way as those of the above respective examples. In

the region 220B, however, only the display switching unit 220 includes the polarizing plate 214 and the display unit 210 does not exist, and therefore, the portion within the region 220B of the display switching unit 220 including the polarizing plate 214 functions as a display body. In case of the drawing, the region 220B forms a transmissive liquid crystal display body. This embodiment can realize a display mode in the region 220B independent of the portion of the region 220A.

[0110]

[Seventh Embodiment]

A seventh embodiment according to the invention will be described with reference to Fig. 11. As illustrated in Fig. 11(b), in a display 600 of the seventh embodiment, polarization converting means 630 is interposed between the display unit 610 and the display switching unit 620. The display 600 can be constituted in the same way as those of the first to the fourth structural examples and the first to the sixth embodiments, except that the polarization converting means 630 is disposed, and further, another structure having the essential components of the invention can be adopted.

[0111]

In this embodiment, a polarization emitted from the

display unit 610 is converted into a different polarized state by the polarization converting means 630 and the converted polarization is entered into the display switching unit 620. The display switching unit 620 is formed in a switchable way between a transmissive state of the light emitted from the display unit 610 and an outwardly-reflective state of the light entered from the outside, by switching the optical state of the liquid crystal panel 622. Thus, according to the function of the display switching unit 620, the display state capable of recognizing a display mode of the display unit 610 visibly and the mirror state capable of recognizing the mirror mode visibly can be realized in a switchable way.

[0112]

The function and effect of this embodiment will be described, by comparison with the display 500 having no polarization converting means 630. For the sake of brief description, assume that lights emitted from the display units 510 and 610 are straightway polarizations and that the liquid crystal panels 522 and 622 of the display switching units 520 and 620 can be switched between a state of rotating the polarization direction by 90 degrees and a state of no changing the polarization state. Further, assume that the polarization converting means is a retardation plate of half wavelength.

[0113]

Substantially similarly to the contents described above, in the display 500, in a display state, a first polarization that is a straightway polarization emitted from the display unit 510 is transmitted through the reflective polarizing plate 521 and entered into the liquid crystal panel 522 as it is, and the direction of the polarization vibration surface is rotated by 90 degrees by the liquid crystal panel 522, hence to be a second polarization that is a straightway polarization, and it is transmitted through the polarizing plate 523 and recognized.

[0114]

In the mirror state, when an outside light is entered, it becomes the second polarization that is a straightway polarization by passing through the polarizing plate 523, and since the second polarization is not changed in the polarized state even after passing through the liquid crystal panel 522, it is reflected by the reflective polarizing plate 521 and emitted from the polarizing plate 523 after passing through the liquid crystal panel 522 again.

[0115]

In the display 500, the light emitted from the display is the second polarization (a straightway

polarization having a vibration surface in parallel with the paper of the drawing) even in any state of the display state and the mirror state.

[0116]

While, in addition to the structure of the display 500, the above mentioned polarization converting means 630 is provided in the display 600, and the display 600 is different from the display 500 in that the polarized-light transmitting axis of the reflective polarizing plate 621 intersects with the polarized-light transmitting axis of the reflective polarizing plate 521 at right angles and that the polarized-light transmitting axis of the polarizing plate 623 intersects with the polarized-light transmitting axis of the polarizing plate 523 at right angles. Namely, the display switching unit 620 of the display is disposed in a state of rotating the display switching unit 520 of the display 500 around the light axis by 90 degrees.

[0117]

By transmitting a first polarization emitted from the display unit 610 through the polarization converting means 630 (1/2 wavelength plate), in a display state, the first polarization is converted into a second polarization having a vibration surface intersecting with the first polarization at right angles. The second

polarization is transmitted through the reflective polarizing plate 621 and converted into the first polarization with its vibration surface rotated by 90 degrees in the liquid crystal panel 622, and the first polarization is transmitted through the polarizing plate 623 and recognized.

[0118]

In the mirror state, when an outside light is entered, it becomes the first polarization that is a straightway polarization by passing through the polarizing plate 623, and since the first polarization is not changed in the polarized state even after passing through the liquid crystal panel 622, it is reflected by the reflective polarizing plate 621 and emitted from the polarizing plate 623 after passing through the liquid crystal panel 622 again.

[0119]

In the display 600, the light emitted from the display is the first polarization (a straightway polarization having a vibration surface intersecting with the paper of the drawing) even in any state of the display state and the mirror state. Namely, the light emitted from the display 600 of this embodiment has its vibration surface rotated by 90 degrees, compared with the polarization emitted from the display 500.

[0120]

Generally, in this embodiment, by providing the polarization converting means 630, it is possible to change the relative position of the display unit 610 and the display switching unit 620, and a result, it is possible to change the state of the polarization emitted from the display unit 610 and the display switching unit 620 while keeping the same function as before changing the position. Thus, it is possible to change a light emitted from the display from the straightway polarization having a vibration surface horizontal or at the approximate angle to the straightway polarization having a vibration surface vertical or at the approximate angle, without changing the position of the display unit 610, so that, for example, even a person wearing the polarization sunglasses can recognize the display state and the mirror state visibly. Accordingly, it becomes very easy to change the structure of the display.

[0121]

The same characteristic structure shown in the above first to the sixth embodiments can be adopted also for this embodiment.

[0122]

[Eighth Embodiment]

With reference to Fig. 12, the display 700 of an

eighth embodiment according to the invention will be described. Although the display switching unit 720 constituted in the same way as in the above respective examples and embodiments is provided in the display 700 of this embodiment, the structure of the display unit 710 is a little different. The display unit 710 has a reflective display 110R formed by a polarizing plate 711, a retardation plate 712, a liquid crystal panel 713, and a reflective plate 714, and a front light 715 interposed between the reflective display 110R and the display switching unit 720. Here, the reflective display 110R can be formed by the various well-known reflective liquid crystal display. The polarizing plate 711 and the liquid crystal panel 713 are constituted in the substantially same way as those of the first structural example.

[0123]

The front light 715 has a light source 715a including a LED and a cold cathode, as illustrated in Fig. 15. A reflective plate 715b is disposed near the light source 715a. A light guide plate 715c is disposed near the light source 715a. The reflective plate 715b has a function of concentrating the light of the light source 715a toward the light guide plate 715c. The light emitted from the light source 715a is entered to the end surface of the light guide plate 715c and the incident

light (a light having a high incident angle at the light axis of the display) is substantially uniformly radiated toward the reflective display 710R from the interior of the light guide plate 715c. The light incident into the light guide plate 715c again after being reflected by the reflective display 710R (a light having a low incident angle at the light axis of the display) is transmitted through the light guide plate 715c as it is and entered into the display switching unit 720.

[0124]

Since in this embodiment, the front light 715 that is an illumination device is provided in the display unit 710 on the observation side (on the side of the display switching unit 720) and the reflective display 710R is provided on the opposite side to the observation side of the front light 715, a display mode by using only an outside light and a display mode by using the front light 715 can be realized even if the display unit 710 does not have the reflective semi-transmissive structure (complicated and expensive structure) like the third structural example and the fourth structural example.

[0125]

The same characteristic structure as shown in the first to the seventh embodiments can be adopted also for this embodiment.

[0126]

[Ninth Embodiment]

[0127]

The structure of a ninth embodiment according to the invention will be described. This embodiment can be applied to the above respective structural examples and embodiments in common and it can be also applied to another structure having the essential components of the invention similarly. In the below, an example of applying this embodiment to the display 100 of the first structural example will be described.

[0128]

In this embodiment, the liquid crystal panel 122 of the display switching unit 120 in the display 100 shown in Fig. 1 is formed by a TN liquid crystal panel, namely, by a nematic liquid crystal with the liquid crystal layer 122c twisted by 90 degrees in the thickness direction. In this case, the liquid crystal layer 122c has an optical rotation of rotating the vibration surface of the straightway polarization by 90 degrees. According as the thickness of the liquid crystal layer 122c is decreased, the polarization direction of the incident light cannot follow the intorelance of the liquid crystal and the transmitted light may be colored by the optical rotation distribution effect. Therefore, by providing the display

switching unit 120 on the observation side of the display unit 110, a display image displayed by the display unit 110 is colored and the mirror face in the mirror state realized by the display switching unit 120 is also colored.

[0129]

Here, the thickness of the liquid crystal layer 122c is increased to some degree, and especially when $\Delta n \cdot d = 0.7$ μm and more, the coloring by the optical rotation distribution becomes less according as $\Delta n \cdot d$ becomes larger. Since the thickness of a cell becomes larger according as the $\Delta n \cdot d$ becomes larger, the threshold voltage (Vth) is increased, the response speed becomes slower, and the used amount of liquid crystal is increased, thereby causing such a disadvantage as decreasing the productivity. Taking these points into consideration, it is preferable that $\Delta n \cdot d$ is 1.7 μm and less.

[0130]

Since the viewing angle characteristic is comparatively good in the range of 0.50 μm to 0.65 μm in $\Delta n \cdot d$, the viewing angle can be restrained from narrowing even when the display switching unit 120 is disposed on the observation side of the display unit 110.

[0131]

Fig. 13 shows wavelength distribution in the visible light region of the refraction index anisotropy Δn of the liquid crystal forming the liquid crystal layer 122c of the liquid crystal panel 122. As apparent from this graph, the refraction index anisotropy Δn varies according to the wavelength λ also in the visible light region. In this embodiment, in the display switching unit 120, a parameter $\alpha_m=\Delta n_m$ (λ=450nm)/Δn_m (λ=590nm) indicating the degree of the wavelength distribution in the liquid crystal within the liquid crystal panel 122c is defined. Here, $\Delta n_m(\lambda)$ means the refraction index anisotropy for the light of the wavelength λ. Further, in the display unit 110, a parameter $\alpha_d=\Delta n_d$ (λ=450nm)/Δn_d (λ=590nm) indicating the degree of the wavelength distribution in the liquid crystal within the liquid crystal panel 113 is defined. Here, Δn_d (λ) means the refraction index anisotropy for the light of the wavelength λ. By the way, in the liquid crystal generally used, the parameter α is about 1 to 1.3.

[0132]

In this embodiment, the ratio of α_m and α_d, namely α_m/α_d is a value within the rage of 0.9 to 1.1. According to this, since the wavelength distribution within the visible light region of the liquid crystal panel 122 of the display switching unit 120 and the wavelength

distribution within the visible light region of the liquid crystal panel 113 of the display unit 110 have almost the same inclination, it is possible to restrain the change of color reproducibility of a display image of the display unit 110 when the display switching unit 120 is added to the display unit 110. Accordingly, it is possible to restrain the coloring of white display in the display unit 110.

[0133]

Fig. 14 shows temperature dependency of the refraction index anisotropy Δn of the liquid crystal (nematic liquid crystal) forming the liquid crystal layer 122c of the liquid crystal panel 122 of the display switching unit 120. As apparent from this graph, in the range of -30°C to 70°C, the refraction index anisotropy Δn is reduced gradually according as the temperature is increased. In this embodiment, in the range of -20°C to 60°C, the variation range of the refraction index anisotropy Δn should be within ±8%, namely, the variation range d (Δn) of the refraction index anisotropy Δn should be within the range of ±8% as for the medium value of Δn. This can be realized by selecting a material having a proper temperature characteristic among the known liquid crystal materials and by blending several kinds of selected liquid crystal materials. When the variation

amount is beyond 8%, the display characteristics such as color tone and contrast are rapidly deteriorated. In this embodiment, however, in which the variation amount is set within the range, practically it is possible to restrain from decreasing the transmission of the display switching unit 120 according to the temperature change, restrain from the change of visibility of a display state based on the display unit 110, and maintain the mirror-like ability in the mirror state. Especially, by fixing the variation amount within ±5%, the display quality can be further improved.

[0134]

[Tenth Embodiment]

An electronic equipment 1000 of a tenth embodiment according to the invention will be described with reference to Fig. 16 and Fig. 17. The electronic equipment 1000 includes the display 100 of the above first embodiment. Fig. 16 is a schematic constitutional block diagram schematically showing a display control system of the display 100 to be disposed within the electronic equipment 1000 in the form of combining it with the function realizing means, and Fig. 17 is a schematic perspective view schematically showing the constitutional example (portable telephone) of the electronic equipment 1000.

[0135]

The electronic equipment 1000 comprises a display driving unit 113X for driving the liquid crystal panel 113 provided on the display unit 110 of the display 100, an illumination driving unit 115X for driving the back light 115 of the display unit 110, and a switch driving unit 122X for driving the liquid crystal panel 122 provided on the display switching unit 120. The display driving unit 113X, the illumination driving unit 115X, and the switch driving unit 122X are controlled by a controlling unit 100X. The above structure shows a display control system in the form of combining it with the function realizing means, not show the installation structure of the actual circuitry and circuit elements. Accordingly, the respective units may be all formed within the display 100, or they may be formed in the outside of the display 100, that is, in the inside of the electronic equipment 1000 other than the display 100, or one may be formed within the display 100 and the other may be formed within the electronic equipment 1000 other than the display 100.

[0136]

The display driving unit 113X supplies a driving voltage for respectively driving a plurality of pixel regions formed within the liquid crystal driving area of

the liquid crystal panel 113, and for example, in the multiplex driving method or the active driving method, a scanning signal and a data signal corresponding to the scanning signal are respectively supplied in synchronization with a common terminal (scanning terminal) and a segment terminal (data line terminal) of the liquid crystal panel 113. The display data such as the image data is sent from a main circuit of the electronic equipment 1000 to the display driving unit 113X through the controlling unit 100X.

[0137]

The illumination driving unit 115X is to control a power supply to the back light 115 and, for example, to switch the on/off states of the back light 115.

[0138]

The switch driving unit 122X controls a voltage applied to the liquid crystal panel 122 and determines whether the voltage of the threshold and more is applied to one pair of opposed transparent electrodes of the liquid crystal panel 122. When a plurality of pixels are provided in the liquid crystal panel 122, the switch driving unit 122X transmits the driving signals corresponding to these pixels.

[0139]

The controlling unit 100X controls the display

driving unit 113X, the illumination driving unit 115X, and the switch driving unit 122X, so as to perform a control instruction and data transmission on the respective units. For example, in case of making the display switching unit 120 in an optical transmissive state (transparent) and the display unit 100 in a display state, the liquid crystal panel 113 is driven by the display driving unit 113X to make a display and the liquid crystal panel 122 is controlled by the switch driving unit 122X to make the display switching unit 120 in an optical transmissive state. In case of making the display switching unit 120 in an optical reflective state (mirror face) so as to make the display 100 in a mirror state, the liquid crystal panel 122 is controlled by the switch driving unit 122X so as to make the display switching unit 120 in an optical reflective state, and the liquid crystal panel 113 is all cut off (in a shutter closed state) by the display driving unit 113X, or the back light 115 is turned off by the illumination driving unit 115X.

[0140]

As illustrated in Fig. 17, the electronic equipment 1000 of this embodiment can be formed as a portable telephone having a main body 1001 and a display body 2002. In this case, the display 100 is disposed in the

inner portion of the display body 1002 and a display screen 1003 can be recognized by the display body 1002. Thus, depending on various operations and situations, a predetermined display image formed by the display unit 110 can be recognized through the display switching unit 120 that is in an optical transmissive state, on the display screen 1003 or the mirror face state realized by the display switching unit 120 can be recognized. Accordingly, the electronic equipment 1000 of the portable telephone can be used as a mirror.

[0141]

When the electronic equipment 1000 is applied to the portable telephone 2000, as illustrated in Fig. 18, another display screen 2004 different from the main display screen (the same screen as 1003) shown in Fig. 17 may be provided on the outer surface of the display body 2002 in a folded state to cover the main body 2001, and through this display screen 2004, a predetermined display can be recognized visibly without opening the display body 2002 from the main body 2001. In this case, by providing the display 100 in addition to the main display shown by a dotted line in Fig. 16, the display screen 2004 can be recognized by the display 100, separately from the main display screen. In the portable telephone 2000 of this embodiment, a display can be recognized in a

folded state and it can be served as a mirror in a folded state.

[0142]

The display and the electronic equipment of the invention are not restricted to the above-mentioned illustrations only, but it is needless to say that various modification can be added to the above without departing from the spirit and the scope of the invention.

[0143]

[Effect of the Invention]

As set forth hereinabove, according to the invention, the display quality can be improved in a display capable of switching the display state and the mirror state on the display unit by controlling the display switching unit.

[Brief Description of the Drawings]

[Fig. 1] It is a schematic structure view schematically showing a display of the first structural example showing an example of the basic structure according to the invention.

[Fig. 2] It is a schematic structure view schematically showing a display of the second structural example showing an example of the basic structure according to the invention.

[Fig. 3] It is a schematic structure view

schematically showing a display of the third structural example showing an example of the basic structure according to the invention.

[Fig. 4] It is a schematic structure view schematically showing a display of the fourth structural example showing an example of the basic structure according to the invention.

[Fig. 5] It is a schematic cross sectional view schematically showing the structure of the first embodiment of the invention.

[Fig. 6] It is a schematic cross sectional view schematically showing the structure of the second embodiment of the invention.

[Fig. 7] It is a schematic cross sectional view schematically showing the structure of the third embodiment of the invention.

[Fig. 8] It is a schematic cross sectional view schematically showing the structure of the fourth embodiment of the invention.

[Fig. 9] It is a schematic cross sectional view (a) and a schematic plane view (b) schematically showing the structure of the fifth embodiment of the invention.

[Fig. 10] It is a schematic cross sectional view (a) and a schematic plane view (b) schematically showing the structure of the sixth embodiment of the invention.

[Fig. 11] It is a schematic cross sectional view (a) schematically showing a display having the basic structure and a schematic cross sectional view (b) schematically showing the structure of the seventh embodiment of the invention.

[Fig. 12] It is a schematic cross sectional view schematically showing the structure of the eighth embodiment according to the invention.

[Fig. 13] It is a graph showing a relationship between wavelength and refraction index anisotropy of liquid crystal.

[Fig. 14] It is a graph showing a relationship between temperature and refraction index anisotropy of liquid crystal.

[Fig. 15] It is a schematic cross sectional view schematically showing the structural example including a front light of the eighth embodiment.

[Fig. 16] It is a schematic structural block diagram schematically showing the structure of a display control system in an electric equipment including a display.

[Fig. 17] It is a schematic perspective view schematically showing the appearance of the electric equipment (portable telephone).

[Fig. 18] It is a schematic perspective view

schematically showing the appearance of another electric equipment (portable telephone).

[Designation of Reference Numerals and Signs]

100, 200, 300, 400, 500, 600, 700...display, 110, 210, 310, 410, 510, 610, 710...display unit, 111, 311...polarizing plate, 112, 212, 312, 412...retardation plate, 113, 213, 313, 413, 513, 613, 713...liquid crystal panel, 114, 214, 314, 414...polarizing plate, 115, 215, 315, 415...back light, 316, 416...retardation plate, 120, 220, 320, 420...display switching unit, 121, 221, 321, 421, 521, 621, 721...reflective polarizing plate, 122, 222, 322, 422...liquid crystal panel, 123, 223, 323, 423...polarizing plate, 124, 224...polarizing plate, 131...adhesive layer, 132, 133, 134...anti-reflection coat, 630...polarization converting means (retardation plate), 113X...display driving unit, 115X...illumination driving unit, 122X...switch driving unit, 100X...controlling unit, 1000...electronic equipment, 2000...portable telephone

[Designation of Document] Abstract

[Abstract]

[Problem] It is to provide a new structure of a display having a display unit and a display switching unit, which can restrain the deterioration of the display quality including contract deterioration caused by the existence of a display switching unit, coloring, reduction of viewing angle, and blur.

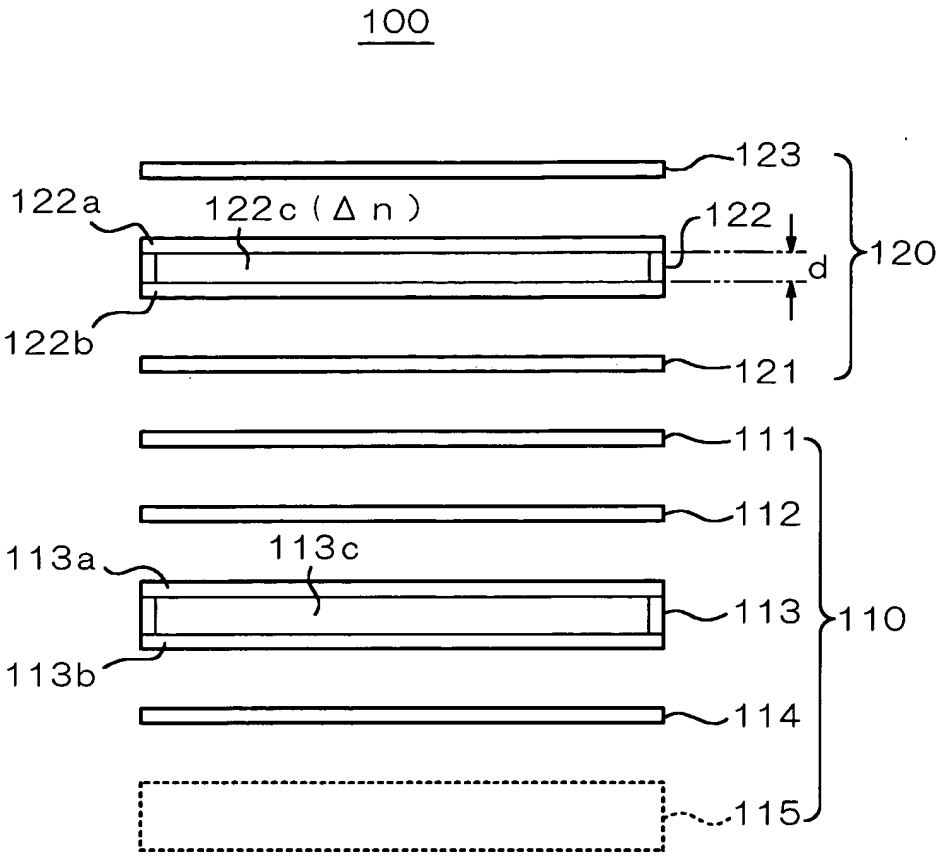
[Means for Resolution] A display 100 has a display unit 110 and a display switching unit 120. The display switching unit 120 is provided with a reflective polarizing plate 121, a liquid crystal panel 122, and a polarizing plate 123 arranged in this order from the side of the display unit 110 to the observation side. According to the control of the liquid crystal panel 122, the display switching unit can be switched between a light transmissive state and a light reflective state. Here, the display unit 110 and the display switching unit 120 are optically adhered to each other by an adhesive layer 131. Thus, deterioration of the contrast by the boundary reflection can be restrained and the flatness

and the rigidity of the device can be improved.

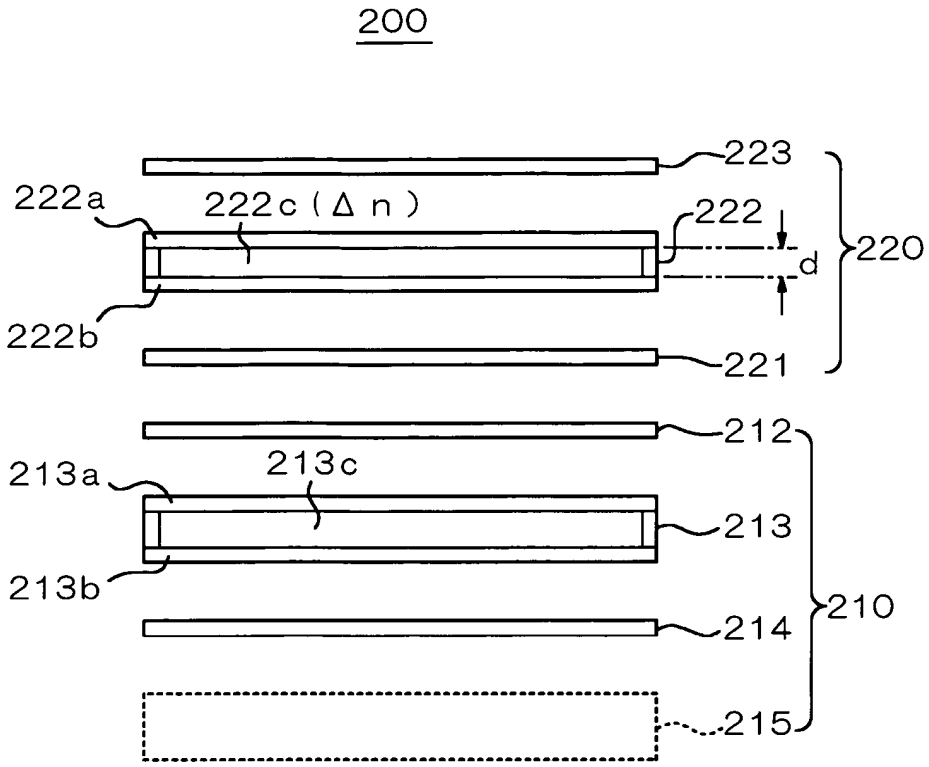
[Selected Drawing] Fig. 5

[Designation of Document] DRAWINGS

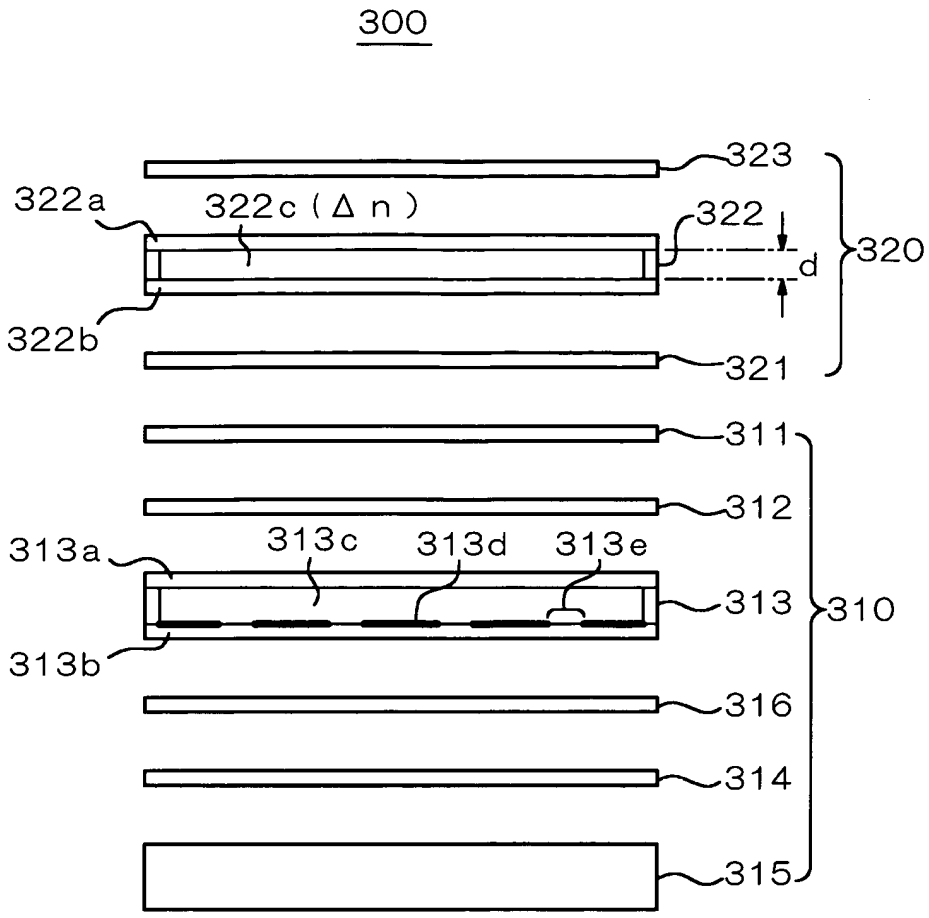
[FIG.1]



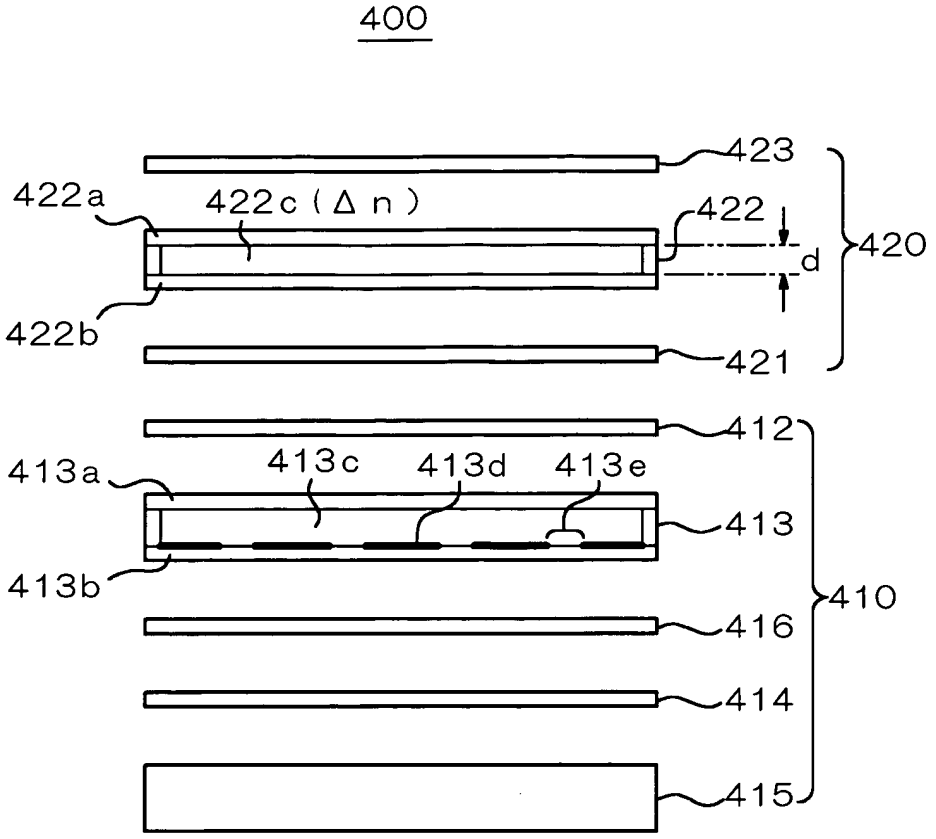
[FIG.2]


200
223
222a
222c (Δ n)
222
d
220
222b
221
212
213a
213c
213
213b
210
214
215

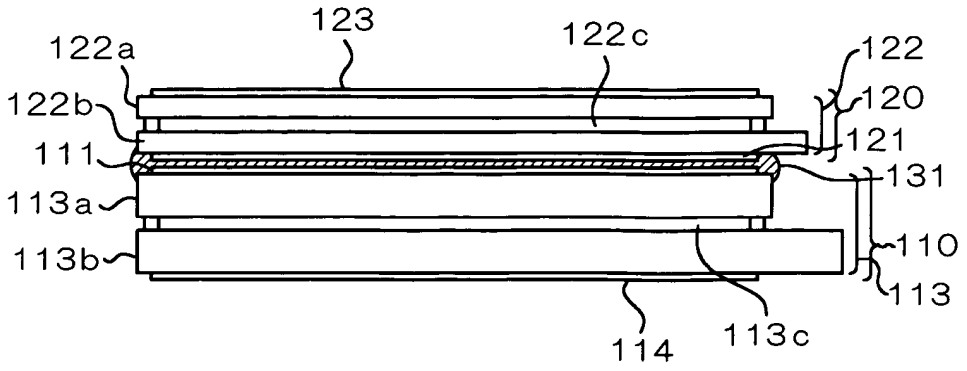
[FIG.3]


300
323
322a
322c (Δ n)
322
d
320
322b
321
311
312
313a
313c
313d
313e
313
310
313b
316
314
315

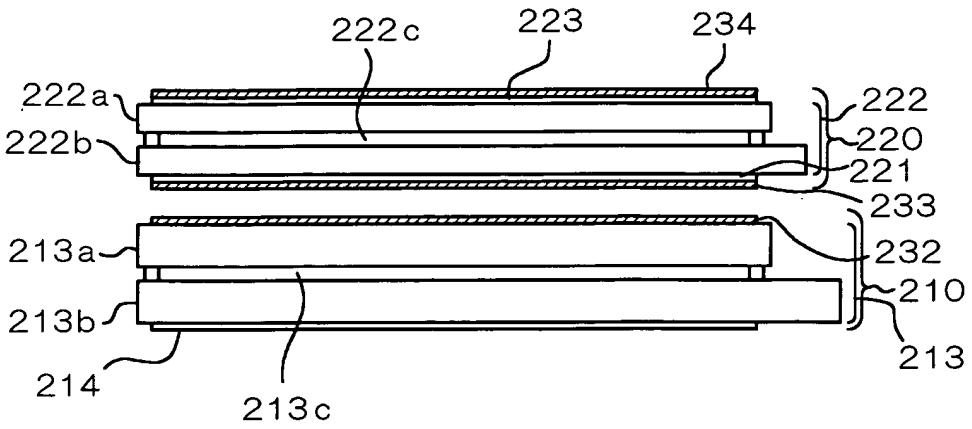
[FIG.4]


400
423
422a
422c (Δ n)
422
d
420
422b
421
412
413a
413c
413d
413e
413
413b
410
416
414
415

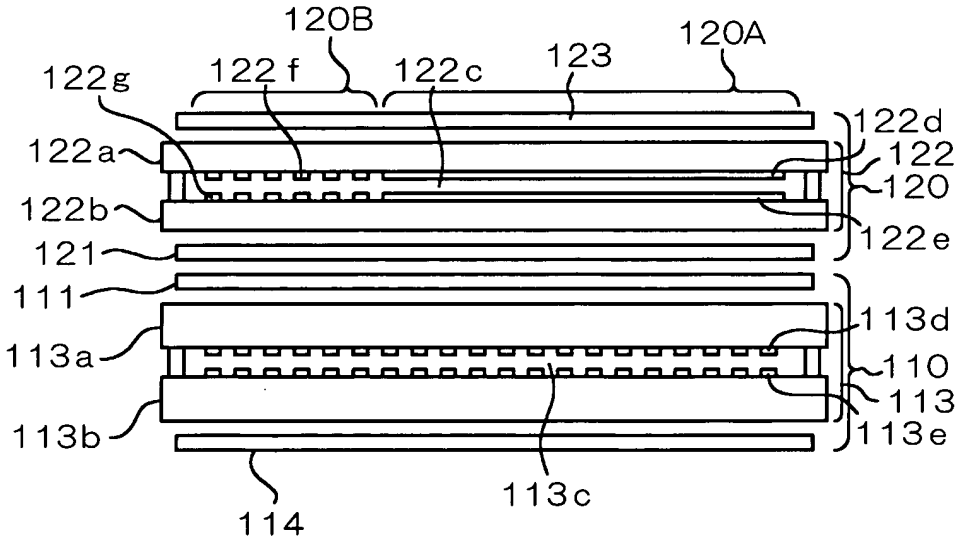
[FIG.5]


123
122a
122c
122
122b
120
111
121
131
113a
113b
110
113
114
113c

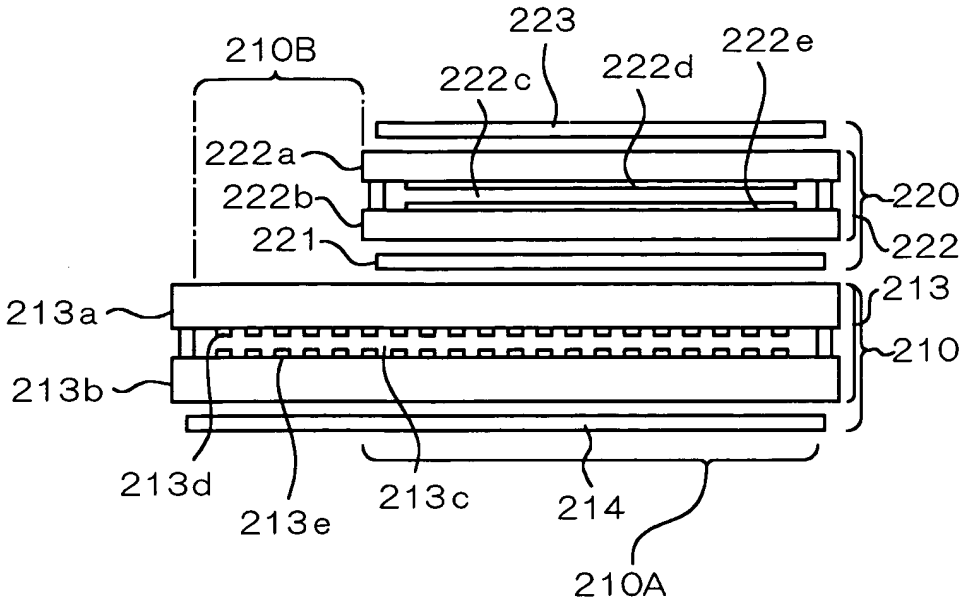
[FIG.6]


222c
223
234
222a
222b
222
220
221
233
213a
232
210
213b
213
214
213c

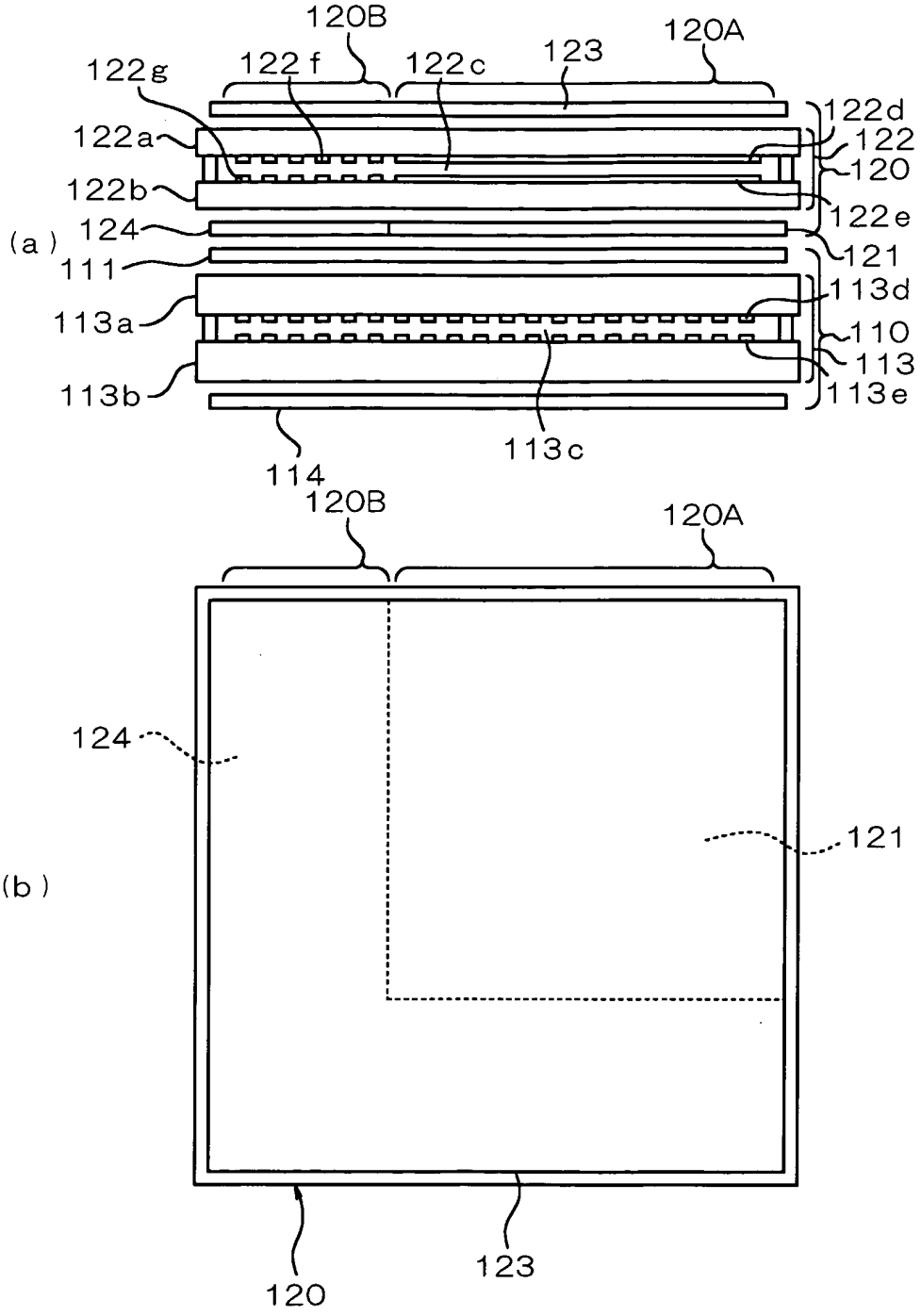
[FIG.7]


120B
120A
122g
122f
122c
123
122d
122a
122
120
122b
122e
121
111
113d
113a
110
113
113b
113e
114
113c

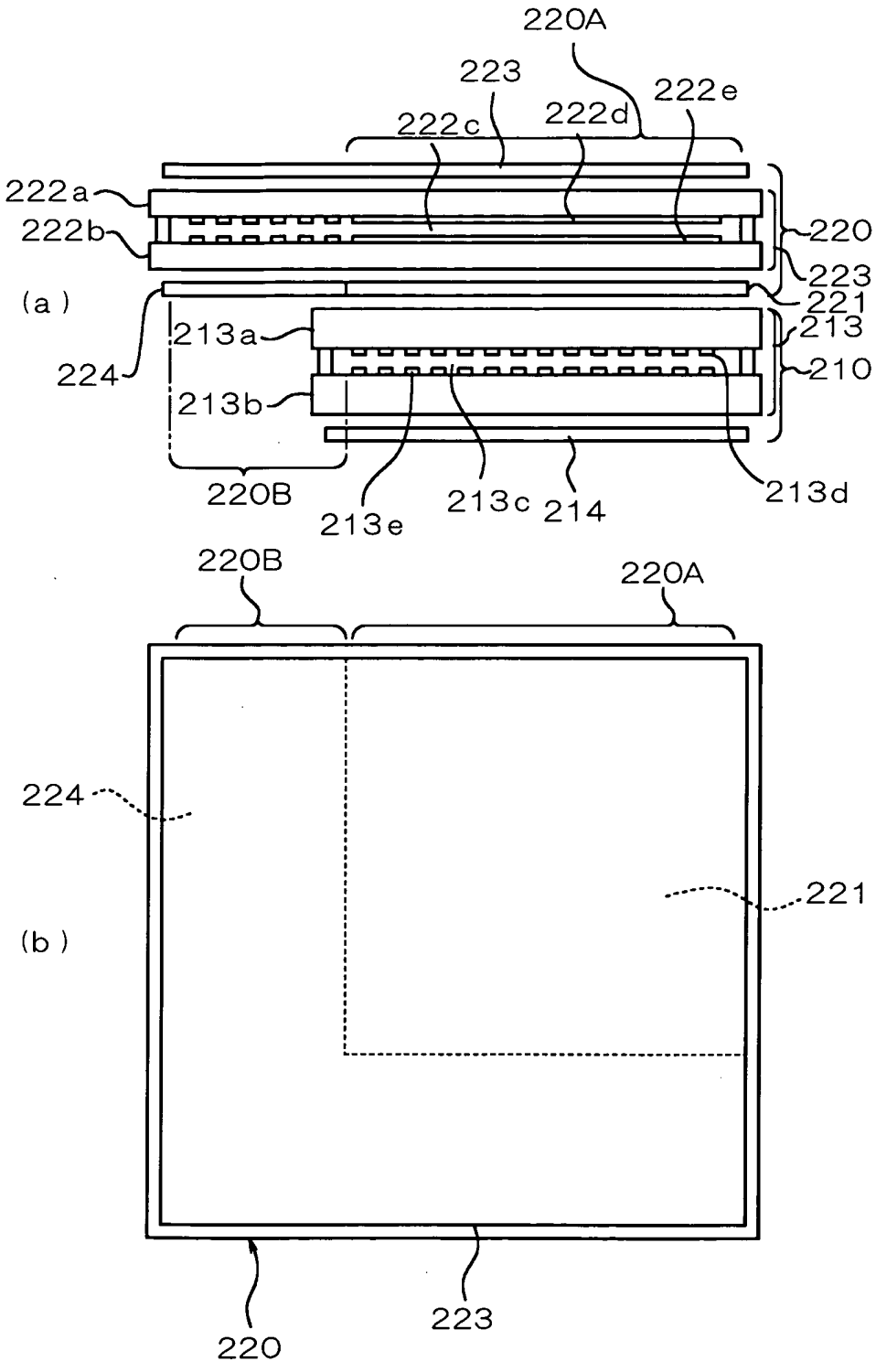
[FIG.8]


223
210B
222c
222d
222e
222a
222b
221
220
222
213a
213
213b
210
213d
213e
213c
214
210A

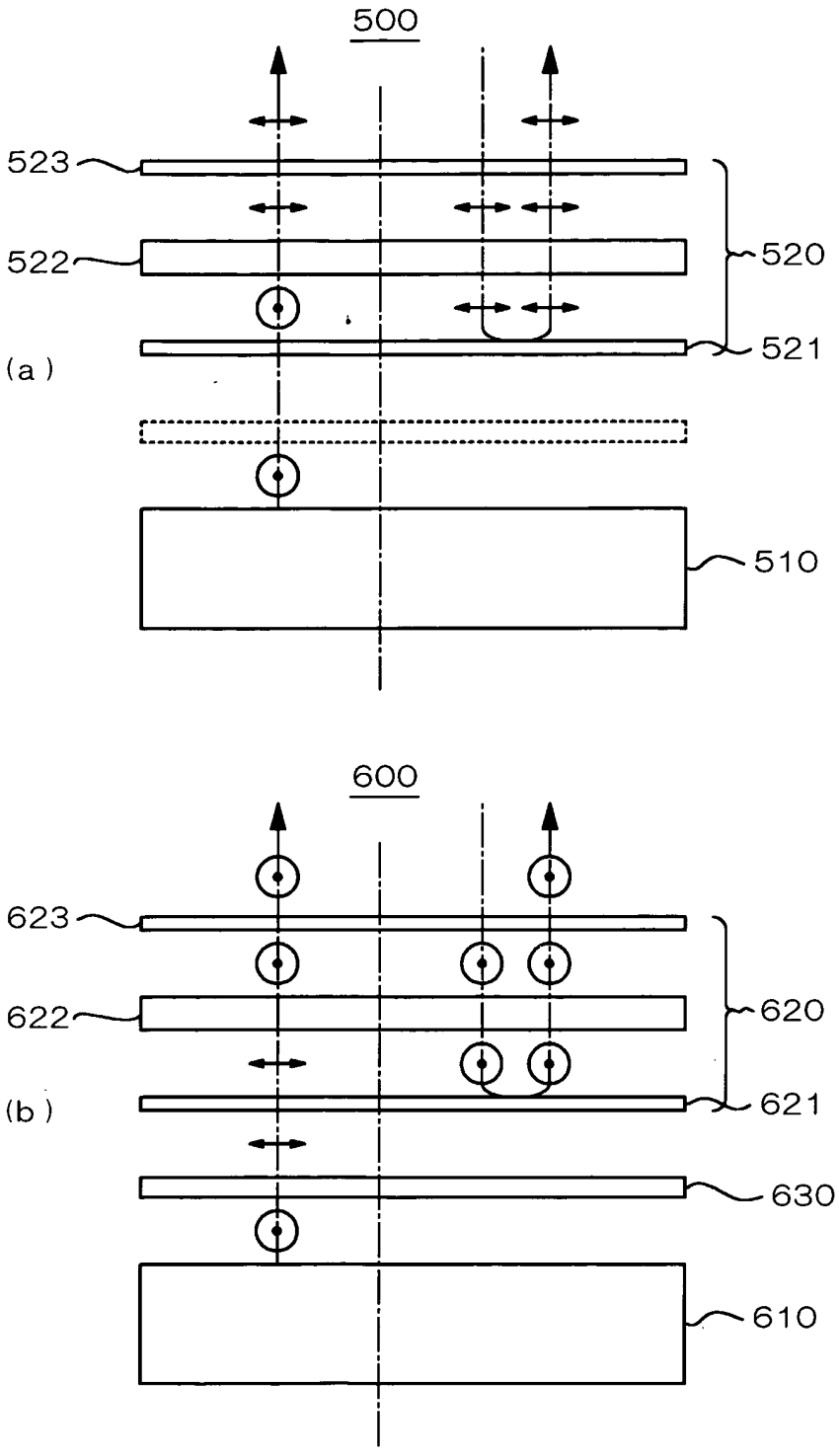
[FIG.9]


(a)
120B
120A
122g
122f
122c
123
122d
122a
122
120
122b
122e
124
121
111
113d
113a
110
113
113b
113e
114
113c
(b)
120B
120A
124
121
120
123

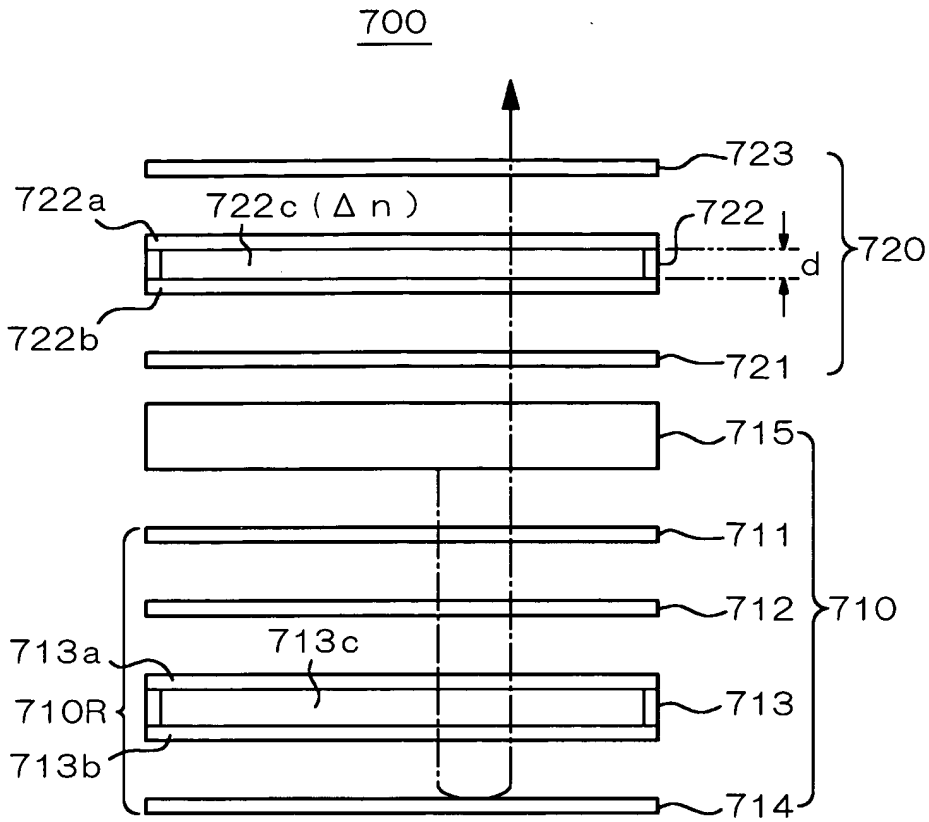
[FIG.10]


220A
223
222e
222c
222d
222a
222b
220
223
221
(a)
213
213a
224
210
213b
220B
213e
213c
214
213d
220B
220A
224
221
(b)
220
223

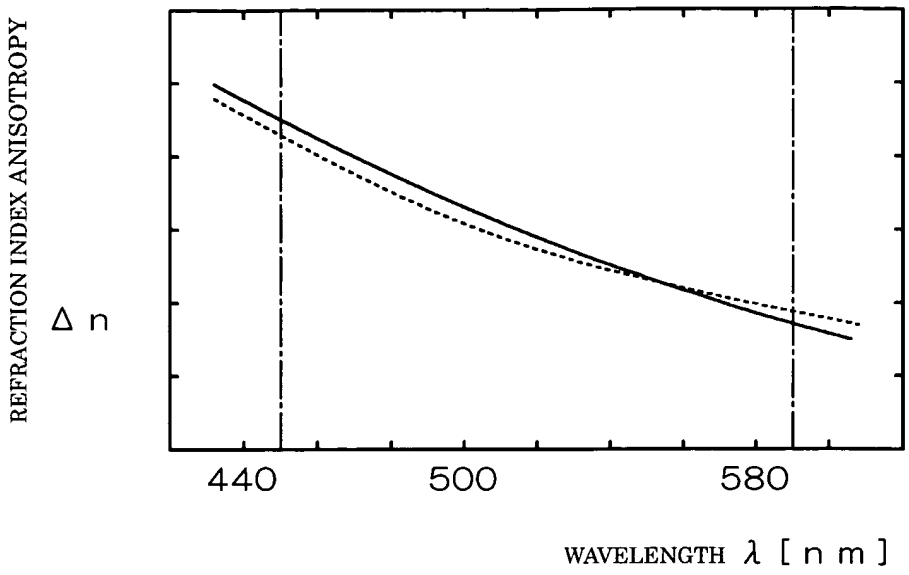
[FIG.11]



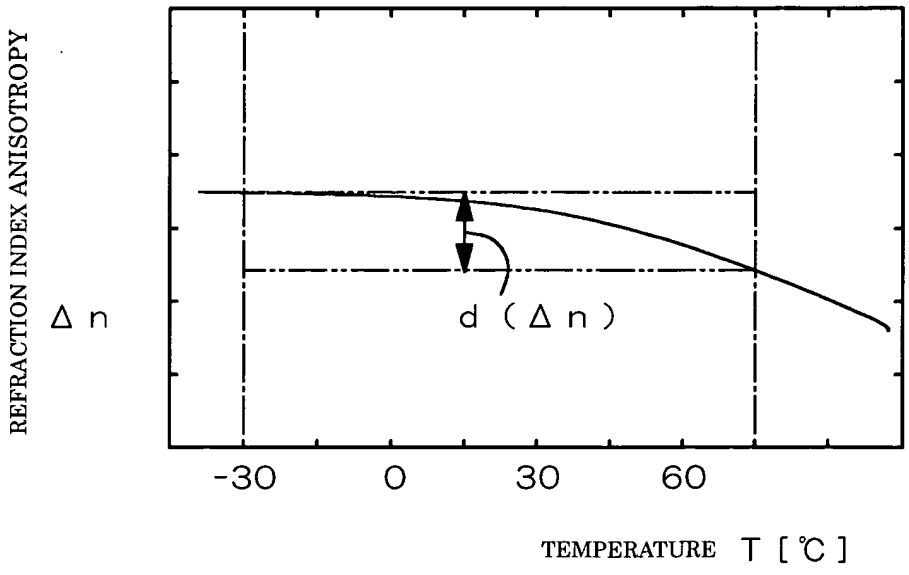
[FIG.12]


700
723
722a
722c (Δn)
722
d
720
722b
721
715
711
712
710
713a
713c
710R
713
713b
714

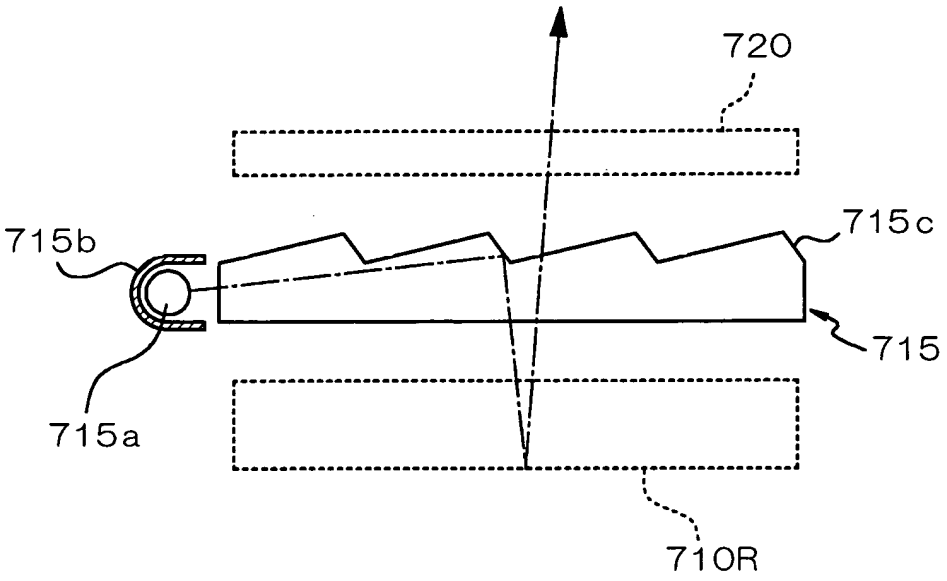
[FIG.13]


REFRACTION INDEX ANISOTROPY
Δ n
440
500
580
WAVELENGTH λ [n m]

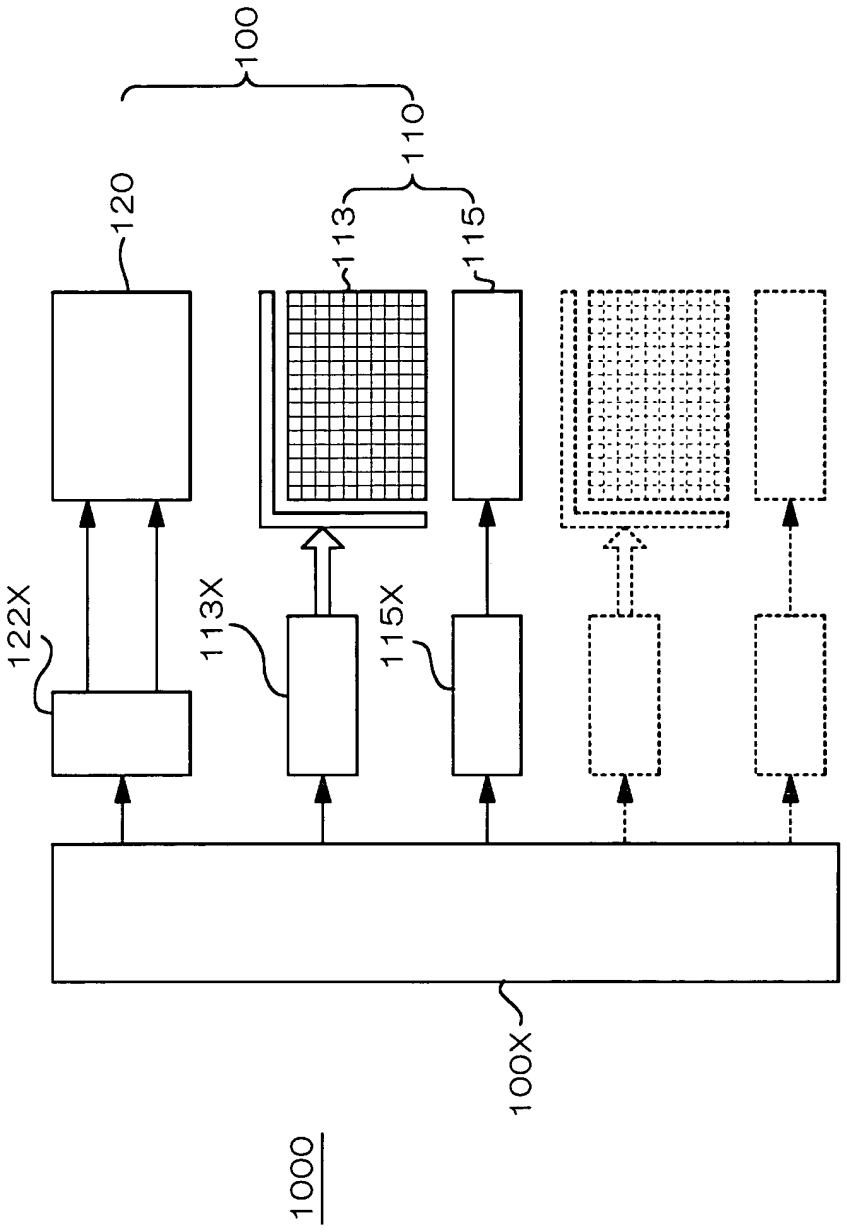
[FIG.14]


REFRACTION INDEX ANISOTROPY
Δ n
d (Δ n)
-30
0
30
60
TEMPERATURE T [℃]

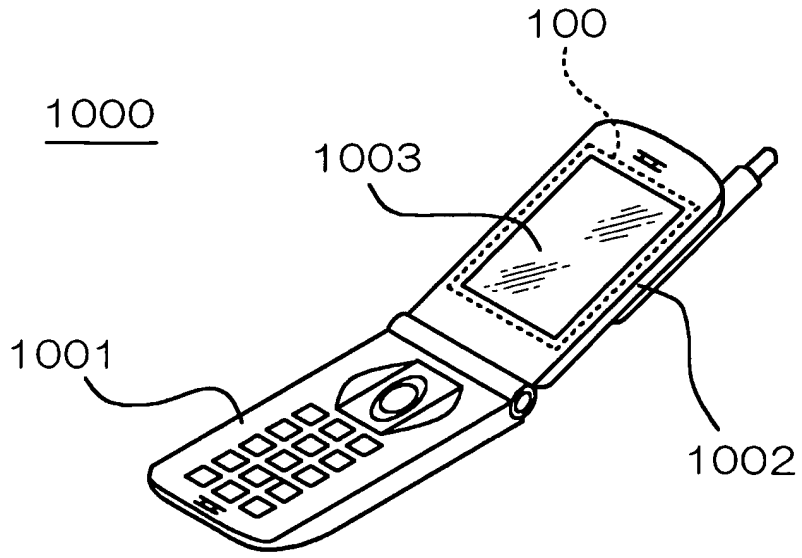
[FIG.15]



[FIG.16]



[FIG.17]



[FIG.18]